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ERRATA.

- Page 33, line 21, for "*obliqua*" read "*obliquae*"
„ 85, lines 34 and 36, for "*labaumeyi*" read "*labaumci*"
„ 88, line 15, for "*fallax*, F." read "*fallax*, Bredd."
„ 145, line 9, for "*memorum*" read "*nemorum*"
„ 162, lines 28 and 35, for "*tesselatum*" read "*tessellatum*"
„ 164, caption to Table iv, for "*tesselatus*" read "*tessellatus*"

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INSECTS ASSOCIATED WITH COCOA *THEOBROMA CACAO* IN MALAYA.

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(PLATES I AND II.)

1. Introduction.

The planting of cocoa in Malaya at the present time must be considered to have reached the experimental stage only, and the data obtained so far are insufficient to warrant a recommendation for its adoption either as a plantation or a small-holder's crop.

Nevertheless, since there is a possibility that, in course of time, cocoa may prove to be a crop likely to yield profitable returns and therefore to be planted more extensively, it has been considered appropriate to publish available information regarding the insects that have been found to be associated with it, in order that intending planters may be able to discriminate between insects of primary and secondary economic importance, and thus be in a position to decide whether control measures are essential in a particular case or not. Insects, however, are not the only cause of damage to cocoa, and some loss is to be expected from the depredations of rats and squirrels which gnaw the pods in order to reach the beans inside. Sometimes pods may be only slightly gnawed but, in spite of that, sufficiently damaged to provide suitable conditions for the propagation of secondary insect pests.

The observations from which the information set forth in the present paper has been compiled were carried out in an area half an acre in extent at the Central Experiment Station, Serdang, Selangor, F.M.S., planted with the "Perak ro" type of cocoa, of which intermediate grades are present. This area was planted in April 1934 from seed raised in Malaya, but owing to a certain amount of mortality among the seedlings, it was necessary later on to fill vacancies. Plants for this purpose were propagated from seeds obtained from Ceylon.

At the time of writing, in addition to this area under cocoa there is another small area in the same plantation which is not yet in bearing, another at the Experimental Station of this Department at Kuala Lipis, Pahang, in bearing, and three small areas planted at different elevations in jungle country near Bentong, Pahang. The trees in these three areas are not yet mature. Apart from these small areas there are a few isolated cocoa trees in various parts of the country. Of the insect pests discussed, the most important are the Capsid bug, *Helopeltis theobromae*, Miller¹², and the beetle *Apogonia cribricollis*, Burm. (MELOLONTINAE), insects which are readily recognisable, the latter being a serious pest of many other kinds of plants.

The genus *Helopeltis* is widely distributed in the Ethiopian, Oriental and Australian zoogeographical regions, species being present in Malaysia, the Philippine Islands, New Guinea, Australia, Burma, India, Ceylon, Tanganyika Territory, Nyasaland and W. Africa, and recorded as feeding on a large variety of plants of unrelated families, many of which are of economic importance.

Since no historical account and no concise list of the many host-plants of the genus has been published hitherto, this information is included herein, and figures of the species known in Malaya up to the present are given for comparative purposes (Plate II).

2. Primary Pests of the Leaf.

As previously stated, by far the most important pests of the leaves of cocoa are the adults of *Apogonia cribricollis*, Burm. These insects begin their activities at dusk, when they quit the soil in which they have lain concealed during the day and fly to the foliage of their host-plant. There is only one flight, which lasts for about one hour. The beetles then settle down to the work of devouring the leaves, which they continue to do until about daybreak, when they return to the soil again.

A. cribricollis is very abundant and, moreover, is a serious pest of many other kinds of plants, among which may be mentioned annatto (*Bixa orellana*), coffee (*Coffea* sp.), rose (*Rosa* sp.), yams (*Dioscorea* sp.), *Dahlia* sp., *Canna* sp., *Zinnia* sp., rambutan (*Nephelium lappaceum*), and gutta-percha (*Palaequium gutta*).

The larvae live in the soil and feed most probably on decaying vegetable matter, but may also attack roots of living plants, particularly if the soil is deficient in their habitual food.

In the control of this insect it should be realized that a more or less continuous vigilance is necessary, and when the beetles are seen to be present, immediate steps should be taken to deal with them. Systematic collection of them by hand combined with chemical treatment of the soil is recommended. For the treatment of the soil 2 oz. of calcium cyanamide should be dug in at a depth of 3 inches near the base of the trees.

Lead arsenate mixed with water in the proportions of 2 lb. of lead arsenate to 50 gallons of water is recommended, and if the spraying is carried out during dry weather, the chemical, having had time to form a deposit on the leaves, will remain effective for some weeks.

Other insects recorded as damaging the leaves are *Plusia chalcytes*, Esp. (Lep. NOCTUIDAE), the larvae of which have also attacked tomato (*Lycopersicon esculentum*); *Nisotra gemella*, Er. (Col. HALTICINAE); and *Hypomeces squamosus*, F. (Col. CURCULIONIDAE), the last named an abundant and conspicuous insect which feeds on a large number of different kinds of plants, those recorded up to the present time in Malaya being lime (*Citrus medica* var. *acida*), rubber (*Hevea brasiliensis*), mango (*Mangifera indica*), jak fruit (*Artocarpus integrifolia*), rambutan, thorny dadap (*Erythrina indica*), pomelo (*Citrus decumana*), cotton (*Gossypium herbaceum*), kapok (*Eriodendron anfractuosum*), sapodilla (*Achras sapota*), cocoa, *Cassia fistula*, *Palaequium* sp., *Mallotus* sp., candlenut (*Aleurites triloba*), *Hibiscus rosa-sinensis*, cow-pea

(*Vigna catjang*), *Evodia* sp., coffee, clove (*Eugenia caryophyllata*), orange (*Citrus aurantiaca*), lemon (*Citrus limonum*), *Derris elliptica*, and *Eugenia jambolana*.

The adult *H. squamosus* measures about 15 mm. in length and is black with a dense covering of pale green or ochreous scales, many of which have a definite metallic lustre.

For the control of the adults of these insects, a lead arsenate spray is effective, but generally it will be less costly to collect them by hand, if they are present in comparatively small numbers only.

3. Primary Pests of Branches and Shoots.

The branches of the cocoa tree are attacked mainly by boring insects, but the question whether an entirely healthy branch is attacked, or whether only those which for some reason or other are suffering from die-back are preferred by such insects, is a debatable one. In the opinion of the writer it is not believed that vigorous plants are extensively attacked.

However, whatever the reason, there is no doubt that attack by boring insects will cause a reduction in the vigour of the plant, and therefore it is considered that they should be placed in the category of primary pests.

In the first rank of importance is the moth, *Zeuzera coffeae*, Nietn. (COSSIDAE), a handsome insect with translucent wings spotted with black and metallic blue. The body which is covered with whitish hair has also some metallic blue spots. The female moth deposits ova in crevices in the bark of a branch, and, on hatching, the larva bores into the centre of it. Continuing to feed, it eventually tunnels for some distance along the centre of the branch. Its presence is revealed by the reddish-brown frass which is ejected from the tunnel.

The spot selected for the deposition of an ovum is towards the end of a branch where the diameter is less and the tissues more tender. Finally, an additional excavation is made in a transverse direction at the end of the tunnel at a spot where the diameter of the branch is greater, consequently the branch is greatly weakened and may easily be snapped off by wind. It is at this spot that the larva, before pupation, bores an exit-hole through which the moth may emerge on freeing itself from the pupal covering. The empty pupa may usually be seen protruding from the exit-hole after the moth has left.

The full-grown larva is approximately 30 mm. in length and is reddish brown dorsally and pale greyish-yellow ventrally. Dorsally, there are sparse whitish hairs arising from raised brownish spots. The prothoracic shield is pale yellow with dark brown confluent spots.

Z. coffeae attacks many plants, among which the principal ones so far recorded in Malaya are, coffee, tea (*Thea sinensis*), cocoa, *Hydnocarpus wightiana*, lime, kapok and cotton. In Java, this species has been recorded on *Cinchona* sp., coca (*Erythroxylon coca*), avocado pear (*Persea gratissima*), soursop (*Annona muricata*), teak (*Tectona grandis*), mahogany (*Swietenia mahagoni*), *Cedrela* sp., sandalwood (*Santalum album*) and rose, in addition to the host-plants recorded in Malaya. *Z. coffeae*, however, is not considered a pest of importance in that country.

One Hymenopterous parasite only (*Glyptomorpha* sp.) has so far been obtained from *Z. coffeae* in Malaya, but in Java several parasites that may have a restricting influence on its abundance are known. *Glyptomorpha* is a Braconid.

Frequent inspection of the cocoa trees should be made and all branches into which this borer has penetrated should be pruned and destroyed by burning.

Young shoots are attacked by the larvae and adults of a Berytid bug, *Gampsocoris pulchellus*, Dall. (Plate II, fig. 5), which deposits its ova singly among the shoots.

The ova are whitish, cylindrical, somewhat curved and rounded at each end, with the surface striate.

Larvae of this species from the 1st to the 4th instars are greenish white. In the 5th instar (Plate II, fig. 7) the colour is as follows :—Green. Eyes reddish ; antennae and legs whitish with dark brown annulations, apical segment of antennae dark brown, apical segments of tarsi suffused with brown ; rudimentary scutellar spine and elevated spots on abdomen ventro-laterally, white ; arcuate stripe on postocular portion of head laterally, longitudinal stripes on pronotum and apex of rudimentary hemielytra, dark brown. In this instar the scutellar spine is indicated by a rounded, smooth, low prominence, and another low prominence is present on the pronotum medially. The rostrum extends almost to the apex of the posterior coxae. In length, the larva of this instar measures 2.7 mm.

The description of the adult *G. pulchellus* is as follows :—Legs and antennae whitish, apical segment of antennae black (except extreme apex), remaining segments with many castaneous annulations which are less distinct on segment 3 ; eyes dark ferruginous ; head and body pale greenish testaceous ; head medially longitudinally, anterior lobe of pronotum posteriorly, posterior lobe medially longitudinally, pale luteous ; scutellar spine and produced portions of metapleurae, whitish ; hemielytra hyaline, faintly testaceous, iridescent ; costal vein castaneous ; wings hyaline, iridescent ; femora and tibiae with many castaneous annulations, apex of segment 1 and apical segment of tarsi castaneous ; abdomen pale greenish testaceous. The adult male measures 3.8 mm. and the adult female 4.3 mm. in length.

As a result of the puncturing of the young shoots, brownish spots, which eventually coalesce, appear, and the shoots eventually wilt. Since, however, pruning of the shoots is carried out at frequent intervals and older and more woody shoots are not suitable for the young larva to feed on, no serious trouble is to be expected from this insect. It has been observed that it also attacks the midribs of the leaves.

Other plants on which this species has been found are *Hibiscus mutabilis* and *Passiflora foetida*, and it was on the former that an instance of adults being attacked by a larva of *Cosmolestes picticeps*, Stål (REDUVIIDAE) was observed. All the stages of this insect are difficult to see unless the shoots are examined very closely. Although no definite observations have been made, it is considered probable that the method of dusting recommended for the control of *Helopeltis* would be equally effective for the control of this species.

Another sucking insect of the same Order, and of very catholic tastes as regards host-plants, is a mealybug, *Phenacoccus iceryoides*, Green (Mem. Dept. Agric. India, Ent. Ser. 11 (2) 1908), which may be found chiefly on the young branches and leaf-stems, but also on the pods.

Apparently it was first observed in 1923 in Singapore, where it was spreading rapidly and seriously damaging rain trees (*Enterolobium saman*). As well as attacking the rain tree, it was eventually found on other plants, namely, *Vitex pubescens*, *Podocarpus australis*, *Bignonia magnifica*, *Claoxylon indicum*, sapodilla, *Phyllanthus* sp., *Ficus alba*, *Poinciana regia*, and *Cassia fistula*.

In 1924, Burkill⁵ reported that *P. iceryoides* had done a great deal of damage among extensive plantings of young rain trees, the pruning of which ensured a continual supply of succulent shoots for the insects. The following year it was reported to be troublesome and as attacking a large number of plants⁶.

The home of this species is most probably Southern India, but it has spread thence to Ceylon, where it has been recorded as feeding on *Tephrosia candida*, *Odina woodier*, *Callicarpa lanata*, *Murraya koenigii*, and *Wendlandia notoniana*¹. In India, mango, *Boswellia* sp., and *Capparis horrida*, are host-plants.

In Tanganyika Territory, where it has been accidentally introduced, cotton and kapok have been attacked, the latter so seriously that it was considered an economic

proposition to import the Coccinellid beetles, *Cryptolaemus montrouzieri*, Muls., and *Rodolia cardinalis*, Muls., from S. Africa, and also to bring a local species of *Chilocorus* into the plantations^{9, 10}.

Later records compiled by the Division of Entomology, Department of Agriculture, S.S. & F.M.S., show that *P. iceryoides* has been discovered on coffee, *Ficus benjamina*, *Plumeria acutifolia*, mango, *Derris elliptica*, *Tephrosia* sp., *Michelia champaka*, *Erythrina lithosperma*, *Murraya koenigii*, *Deguillica microphylla*, *Crotalaria* sp., *Beaumontia* sp., *Tephrosia candida*, *Gardenia florida*, and *Bignonia* sp.

The large number of plants attacked by this species and its capability of relatively rapid spread, for which ants are mainly responsible, indicate that control measures should be instituted as soon as its presence is noticed. The groups of large white ovisacs secreted by the female are very conspicuous and therefore not likely to be overlooked if proper inspection of the trees is the rule. A close examination of the ovisac will reveal that it is composed of a quantity of wax-like powder and silk filaments enveloping the ova, of which a large number is deposited by each female. The ova are elongate in shape and pale yellow in colour, and measure approximately 0.3 mm. in length; the young larvae also are yellow. In each ovisac there are between 100 and 200 ova.

An ant, *Plagiolepis longipes*, Jerd., has been found in attendance on this mealybug and is partly responsible for its spread.

The mealybug attacking cocoa in Java is *Pseudococcus crotonis*, Green. This species is dispersed by the agency of the ant, *Dolichoderus bituberculatus*, Mayr, the presence of which in cocoa plantations has been considered advantageous since, it is said, trees on which they are present are attacked by *Helopeltis* to a far less extent than those from which they are absent. This circumstance led to the artificial colonization of plantations with *D. bituberculatus*, nests of which were collected by natives and attached to cocoa trees. Regarding this method of control, a choice has to be made whether complete reliance is to be placed on it or whether other methods, for example the destruction of *Helopeltis* by flames (see p. 10), by hand-collecting or by dusting should be adopted. It is obvious that the method of passing a flame along pods and branches, or of dusting, could not be practised in plantations in which it was desired to encourage the propagation of colonies of *D. bituberculatus*.

In cases where the insect has spread rapidly over a large number of plants it will be necessary to use a spray to control it, the most suitable being kerosene emulsion, which is prepared by dissolving $\frac{1}{2}$ lb. of soap in one gallon of water and adding to the solution two gallons of kerosene. The resulting mixture should be very thoroughly churned up so that a homogeneous mixture is obtained. When required for use, it should be diluted with nine times the quantity of water and again thoroughly mixed. If sufficient care is not exercised in making the mixture, there is a danger that the kerosene will scorch the plants on which it is sprayed. It is perhaps hardly necessary to add that, when the stock solution is being prepared, the kerosene should not be added while the container, in which the water and soap are being boiled, is still on the fire.

Another member of the order Rhynchota which in both the larval and adult stages occasionally inflicts minor damage to shoots and leaf-stems is a Coreid, *Anoplocnemis phasiana*, F., an abundant and widely distributed insect which feeds on a variety of plants, e.g. egg plant (*Solanum melongena*), *Ipomoea palmata*, rubber, *Passiflora foetida*, loofah (*Luffa acutangula*), *Gliricidia maculata*, thorny dadap, *Cajanus indicus*, lime, and groundnut (*Arachis hypogaea*).

This species, which is widely distributed in India, Ceylon and Malaya, deposits its ova usually in a chain but occasionally singly or in pairs. The ova are dark purplish brown with a covering of fine white wax-like granules. In shape they are cylindrical, somewhat obliquely truncate at each end, a little narrower at the end

through which the larva emerges, and flattened on the side in contact with the object on which they are deposited. The surface at the narrower end is concave and at the broader end convex.

There are five larval instars, all of a dark colour, their most outstanding morphological feature being the widely expanded anterior tibiae. The adult is castaneous, with dense pale castaneous pubescence. Dorsally the abdomen, except laterally and apically, is rufo-ochreous. The legs and antennae are picuous, with dense short castaneous pubescence; apical segments of antennae rufo-ochreous, except basally. A striking feature of the adult male is the greatly thickened posterior femora. In the female these appendages are less robust.

A. phasiana is a minor pest and can be adequately controlled, if considered necessary, by collecting all stages by hand.

4. Primary Pests of the Pods.

The principal primary pest of the pods is *Helopeltis theobromae*, Miller¹², the life-cycle of which has been worked out, the details being as follows:—

Ovum (Plate II, fig. 4).—White, glabrous, operculum with an infumate spot; minutely reticulate; cylindrical, narrower apically than basally and laterally compressed apically; opercular processes of unequal lengths. Length 1·2, including longer process, 1·6 mm. Incubation period 6–7 days.

First instar larva (Plate II, fig. 2).—Ochreous, faintly suffused with ferruginous; eyes sanguineous; legs pale ochreous with irregular suffused infumate maculation, tarsi fuliginous; abdomen sanguineous; setae black. Basal segment of antennae much thicker than remaining segments; all segments of antennae and legs with sparse, moderately long erect setae. Head and thorax with a few erect setae. Abdomen with two parallel rows of setae sub-dorsally and a few setae laterally. Rostrum extending almost to apex of abdomen in a recently emerged larva, but soon after the larva has fed the abdomen becomes distended and consequently increases in length, the rostrum then extending to the base of the abdomen. Length 0·50 mm. Period of 1st instar 5–6 days.

Second instar larva.—Green; basal segment of antennae hyaline, faintly ochreous and fuliginous, segment 2 pale testaceous with vinaceous maculation, segments 3 and 4 vinaceous; eyes dark vinaceous; scutellar spine green, becoming reddish ochreous towards apex; femora and tibiae pale ochreous with irregular fuliginous annular maculation, tarsi fuliginous. Antennae more than twice as long as head and body together, basal segment thick. Scutellar spine cylindrical, shorter than head. Length 1·5 mm. Period of 2nd instar 3 days.

Third instar larva.—Green; basal segment of antennae ochreous, apically fuliginous, segments 2, 3 and 4 reddish castaneous; eyes dark vinaceous; scutellar spine reddish ochreous; femora and tibiae ochreous, with faint fuliginous annulations; tarsi fuliginous. Scutellar spine more or less cylindrical, obliquely truncate apically and without a club, in length sub-equal to the head. Length 2·9 mm. Period of 3rd instar 3 days.

Fourth instar larva.—Basal segment of antennae ochreous with faint fuliginous annulation, segment 2 ochreous suffused with vinaceous apically, segments 3 and 4 vinaceous; eyes sanguineous; head pale olivaceous with a sanguineous postocular stripe laterally; thorax olivaceous; rudimentary hemielytra suffused with ochreous; scutellar spine reddish ochreous; abdomen green with a faint vinaceous suffusion mid dorsally; femora and tibiae ochreous with fuliginous spots and annulations, tarsi fuliginous. Rudimentary hemielytra extending to the apical margin of the 1st abdominal segment; scutellar spine subequal to the head and rounded apically. Length 3·5 mm. Period of 4th instar 3 days.

Fifth instar larva (Plate II, fig. 3).—Green; rudimentary hemielytra olivaceous, very narrowly blackish along inner margin; scutellar spine suffused with castaneous; basal segment of antennae olivaceous basally becoming ochreous towards apex with suffused fuliginous spots, segment 2 testaceous becoming reddish castaneous towards apex, segments 3 and 4 reddish castaneous; eyes sanguineous; femora greenish basally, ochreous towards apex, suffused with castaneous apically, with castaneous spots; tibiae ochreous suffused with fuliginous basally and with dark castaneous suffused spots; tarsi fuliginous; vertex suffused with fuliginous and with a pale V-shaped area. Basal segment of the antennae relatively more slender than in previous instars; rudimentary hemielytra extending to the apical margin of the 4th abdominal segment and the rostrum to the anterior margin of the posterior coxae. Length 4.00 mm. Period of 5th instar 3 days.

Adult (Plate II, fig. 1).—Male: antennae with segment 1 testaceous, apically piceous, basally green, tubercles piceous, remaining segments piceous; eyes piceous; head green; vertex and clypeus suffused with piceous, rostrum testaceous; thorax piceous with an ochreous spot on posterior lobe laterally; scutellum testaceous, suffused with piceous basally, apex piceous; pro- and mesosterna piceous, metasternum green, meso- and metapleurae green, abdomen green; femora testaceous with suffused piceous spots; tibiae testaceous, basally piceous and with some interrupted piceous annulations in basal half; hemielytra hyaline, faintly infumate and iridescent, cuneus and venation pale testaceous, infumate. Female similar to male, except that the pronotum is entirely ochreous, with a broad transverse piceous stripe between anterior and posterior lobes, and with the posterior margin of posterior lobe suffused with piceous; scutellar spine piceous (basally ochreous), and the abdomen dorsally with broad transverse black spots.

Antennae with the basal segment moderately thick, minutely tuberculate and setose, thicker apically, longer than head, pronotum and scutellum together; segment 2 slender, minutely tuberculate and setose, nearly twice as long as segment 1; segment 3 a little shorter than 2, with abundant short setae; segment 4 a little more than one-third as long as 3, with abundant short setae. Eyes prominent, ovate; head a little wider than long, measured between the eyes, less than half as long as pronotum; tylus with minute setigerous tubercles; internal margins of antennal tubercles moderately prominent; basal segment of rostrum extending to middle of postocular. Scutellum with apical spine erect, feebly curved, longer than pronotum. Hemielytra extending beyond apex of abdomen by about one-third of their length. Femora somewhat nodulose and sparsely tuberculate; tibiae with abundant low setigerous tubercles; apical segment of tarsi a little longer than remaining two segments together.

In living specimens the apex of the scutellar spine is spherical, but shortly after death, the membranous apical area collapses, with the result that the spine appears truncate apically.

<i>Measurements</i>			<i>Male</i>	<i>Female</i>
Total length	...	...	4.8 mm.	5.7 mm.
Hemielytra	...	...	4.8 mm.	5.5 mm.
Greatest pronotal width	...	...	1.3 mm.	1.5 mm.

This species is apparently allied to *H. romundi*, the original description of which by Waterhouse is as follows:—Black and shining, legs pale dirty yellowish, mottled with light brown. Scutellar spine pale dirty brown, pale yellow at the base, formed as in *H. bradyi*, very little curved, slender. Abdomen with a narrow line of yellow at the sides of the basal segments. Legs much paler than in *H. bradyi*. Pronotum red with a dusky line near front margin. Scutellar spine longer than in the male and distinctly curved, a character in which it differs from both *H. bradyi* and *antonii*. Abdomen with more yellow at the sides. The rest as in male¹.

The larvae and adults of *H. theobromae* are active, but somewhat delicate, shade-loving insects and flourish most in those areas in which they can obtain protection from the sun, heavy rains and strong winds. The adults, when disturbed, do not fly far, as a rule, but usually alight on another part of the plant or on a plant close at hand. Larvae endeavour to conceal themselves by running round to the opposite side of the pod, or sometimes they remain motionless, in which condition they are somewhat difficult to detect owing to the similarity between their green coloration and that of the pod. Male and female adults resemble each other closely but may be distinguished in the first place by the difference in size, the female being more robust with a more globose abdomen.

In common with other species of this genus, *H. theobromae* deposits its ova singly or in small groups in the tissues of its host-plants, the ova being entirely concealed except for the upper surface of the operculum and the two filamentous processes on each side of it. The extremely small portions of the ova which are exposed render them very difficult to discover, unless the part of the plants in which they are present is held against a dark background. If this is done, the white apical processes can be seen distinctly. Concealment of the ova is even more effective when they have been deposited in young shoots of cocoa, particularly of those varieties in which the pubescence is very dense. Regarding the sites for oviposition in the cocoa plant, it would seem that *H. theobromae* is influenced by the presence or absence of pods, and if pods are present, prefers to deposit ova in them rather than in shoots. The reason for this preference is, no doubt, due to the fact that the shoots have a pubescent covering which is extremely dense in certain varieties and which can, but does not always, hinder oviposition. At all events, the pubescence must provide a relatively important obstacle to oviposition, but although there is hardly any difference in the degree of toughness of the outer covering of shoots and pods, the latter are evidently more suitable. *Helopeltis* spp. have been recorded by other investigators as ovipositing in the leaf-stalks of cocoa in the field, but this method has not been observed in respect of *H. theobromae*.

The entire life-cycle of *H. theobromae* is spent on the tree in which the ova were deposited, so that if there has been extensive oviposition severe damage will result from the feeding of the larvae, which on attaining the adult stage may remain for some time on the same tree. These adults may then oviposit there, so that from the time of forming to the time of ripening the pods are continually exposed to attack by several generations of larvae and adults. Frequently, larvae of all instars and adults may be observed together on the same tree.

With cocoa grown at low elevations, the time that the pods take to mature is from 5 to 6 months. This being so, assuming that the larvae from successive batches of ova remain on one tree, at least six generations of *H. theobromae* would be able to develop and inflict serious damage. Fortunately, however, this rarely, if ever, happens since *H. theobromae* is influenced by weather conditions, particularly by periods of drought, during which it seeks localities where it will find moist conditions, for example, along streams or in denser vegetation than is usually present in cocoa plantations. The fact that several generations do not remain on a single tree may be demonstrated by an examination of a number of trees and by a count of pods damaged and undamaged. It will be noticed then, how uneven is the extent of damage, some trees bearing pods, all of which show signs of attack, other trees with the majority of pods free from the characteristic spotting.

A superabundance of flowers is produced by the cocoa tree, but only an extremely small proportion of them remain on the tree and eventually produce pods, and of those pods produced, a further reduction takes place by a normal fall (if the tree has produced more pods than it is capable of carrying), which should not be confused with the occasional fall of immature pods brought about by repeated wounding by *Helopeltis*.



a, b; Cocoa pods attacked by *Helopeltis*.

c, d; Cocoa pods attacked by *Dichrocrocis punctiferalis*, Guen.

An endeavour was made to ascertain the extent to which *H. theobromae* might be responsible for the premature fall of pods and for the retardation of development and distortion of pods, but without success. It was found that pods which had attained a length of barely an inch turned black and fell without having been attacked and also if slightly attacked. On the other hand, many pods which had developed and ripened had been severely punctured, so as to be almost entirely covered with brown and black circular spots characteristic of the results of piercing by *Helopeltis*. In such pods, however, development is apparently normal and no deterioration of the seeds has presumably taken place, judging from the condition of those taken from badly discoloured pods.

Although produced in the same manner, the ultimate effect of the piercing of the tissues of pods and shoots by *Helopeltis* is not the same, the pods exhibiting circular brown spots which eventually become black and scab-like (Plate I), but the areas on the shoots where feeding has taken place become pale brown, elongate and depressed. Eventually the discoloured areas coalesce, and if several punctures have been made in close proximity to each other, decay sets in.

The mechanical action of the insertion of the mouth-parts of the insect is not responsible for these phenomena, these being due to the saliva which is injected by the insect when about to feed. Several workers have investigated the chemical physiological properties of the saliva of Hemiptera, and, according to Weber⁹, it contains starch-dissolving ferments. During feeding, the saliva injected by the insect is not entirely sucked up, with the result that it has a deleterious effect on the tissues and prepares the way for the ingress of saprophytic fungi.

In view of the fact that a single *Helopeltis* is capable of making more than one hundred punctures in the course of twenty-four hours, it is not a matter for astonishment that small pods are unable always to recover from attacks. Yet, as previously mentioned, in certain instances the attack may be very severe, and although the pod concerned may have an extremely unsightly appearance, as a result of the attack, the seeds appear to be unaffected. Whether the quality of cocoa prepared from such seeds is not of the same standard as that from seeds out of sound pods is unknown. Some damage obviously is caused by the oviposition of *Helopeltis*, but this is not of a serious nature and is not conspicuous.

For the purpose of obtaining information regarding the extent of damage that *H. theobromae* is able to cause in the field, single pods and several pods on a branch were enclosed in glass cylinders with the open ends covered with muslin, and in mosquito-netting sleeves respectively. The pods, however, were adversely affected by being enclosed, some turning black within a week, so that the attempt to assess the damage that *H. theobromae* is capable of causing was abandoned.

During the period in which observations were being made on this species a certain fluctuation in numbers was apparent. The reason for this is possibly to be ascribed to weather conditions, for example, during February and early March of 1939 a marked reduction in numbers was observed. This, it is believed, was due to the somewhat abnormal dry period which prevailed then. An additional possible reason for the comparatively sudden decrease in numbers may have been the drastic pruning of the shade trees, which of course would have the effect of unfavourably altering the ecological conditions in which this species thrives.

No definite information has been obtained regarding the natural enemies of *H. theobromae*, but there is no doubt that a certain number of larvae and adults are victims of insectivorous birds, spiders and Reduviid bugs; the last named, however, are not particular in their choice of insect food, as a rule, so that they cannot be considered as definite enemies.

A Hymenopterous larval parasite, *Euphorus helopeltidis*, Ferr., with a hyperparasite, *Stictopisthus javensis*, Ferr., have been obtained in Java from *H. antonii*, but up to the present no parasites have been obtained in Malaya⁷.

For the control of this species, dusting is probably the most satisfactory method. In the area in which the investigations were carried out, experimental dusting with pyrethrum-lime dust (1:2) was carried out on two occasions at an interval of a week, the second dusting being essential, since the ova of *H. theobromae*, being embedded in parts of the plant, are not affected by the dust.

This method was effective in almost entirely eliminating the insect, but it should be mentioned that dry weather conditions prevailing at that time no doubt enhanced the efficacy of the treatment. An inspection of the area at intervals, and finally seven months after the dusting was carried out, showed, however, that the treatment was effective, apparently irrespective of the influence of weather conditions.

The cost of the operation, exclusive of the cost of apparatus and labour, was approximately \$1.80 (Straits currency); the time occupied was one hour and the dusting apparatus used was a rotary hand duster with a single nozzle. The same method has proved effective against *H. bergrothi*, Reut., in Tanganyika Territory, where it is recommended for the control of that species. It was demonstrated that a light dusting killed all adults on young avocado plants in the laboratory, and no adults were discovered in a mixed nursery five days after dusting at the rate of 8 lb. of pyrethrum per acre¹¹.

Some years ago, in Java, a recommendation for dealing with *Helopeltis antonii*, Sign., was made which entailed the use of flares or small kerosene-burning lamps, the flames of which were passed over the pods of cocoa³. Since no mention that this practice has been continued has been found in the literature published in recent years, it is assumed that it has fallen into disuse.

Hand collection was also recommended, the collectors employed being small children armed with sticks to which an adhesive substance—e.g. the latex of the jak fruit—had been applied. Alternatively the sticks had small tufts of kapok attached to them.

5. Secondary Pests of Branches and Shoots.

Branches which have died as a result of boring by the larvae of *Zenusa coffeae* are an attraction to boring beetles of the family SCOLYTIDAE, one species of which, *Xyleborus abruptus*, Samps., has come to notice during the course of these investigations. In general, representatives of this family prefer dry or almost dry wood and can be important pests of unseasoned timber. The adult *X. abruptus* is castaneous in colour with the elytra piceous posteriorly. It measures 3.5 mm. in length.

A common name for the SCOLYTIDAE is ambrosia beetles. They do not bore into wood for the sake of eating it but for the purpose of obtaining a suitable environment for a fungus which grows on the walls of the tunnels, each group of beetles having its specific fungus. This cultivation of a food by an insect may appear remarkable, but actually it is only an instance of a symbiotic relationship between an insect and a fungus. If the beetles and their larvae are not numerous enough to regulate the growth of the fungus by consuming it, they will eventually be overcome by it. Again, if conditions are not entirely suitable, as an outcome of changed physical and chemical conditions within the wood, the beetles and their larvae may be starved owing to the inadequacy of the quantity of fungus available.

In another section mention is made of two other species of SCOLYTIDAE, *Xyleborus similis*, Ferr., and *X. torquatus*, Eich., discovered in decaying pods, to which they had no doubt been attracted by fermentation products therein. The liking for such products is illustrated at times by reports of beetles of the family boring into casks containing wine or in which wine had been stored at some time previously.

To avoid providing suitable conditions for the propagation of these beetles it is therefore important to inspect periodically all trees on which injured and dying

branches are present. Such branches should be lopped, removed from the plantation and burned.

6. Secondary Pests of the Pod.

The presence of secondary pests in a plantation is frequently an indication that clean cultivation is not assiduously practised, and that the plants singled out for attack by insects are not as robust as they should be. The object, therefore, of this section, which might appear redundant, is to bring to notice numerous insects, many of which are primary pests in respect of other plants or plant material, and which are encouraged to multiply and spread, if the practice of clean cultivation is neglected.

Weakness and the dying back which often follows attract various insects, such as boring beetles and moths, which deposit their ova in crevices on branches which are not entirely healthy and in pods suffering from disease or from injury caused by rodents. Dead pruned branches and pods that are dead or severely bored by Lepidopterous and Coleopterous larvae should not be allowed to remain on the plantation, but should be removed and destroyed by burning. Dead pods and portions of branches left lying on the soil will soon attract termites, the species observed during the present investigations being *Microtermes pallidus*, Hav., and *Termes javanus*, Holmgr. Both these species have been known to attack plants which are weakly or injured.

Pods which have succumbed to repeated attacks by *Helopeltis*, and those in which decay due to other causes has set in, become infested by numerous other insects, mainly Coleoptera. Of these the most important is *Araecerus fasciculatus*, de Geer (ANTHRIBIDAE), a pest primarily of leguminous seeds (e.g. *Tephrosia* spp., and *Crotalaria* spp.), but which has also been recorded from cotton, coffee, kapok, soya beans, egg-plant, Brazil nuts, araca nuts, avocado pear seeds, rubber seed cake, *Bruguiera caryophylloides*, Bl., *B. eriopetala*, Wight., and *B. gymnorhiza*, Lam. (Rhizophoraceae).

In addition to the seeds of these plants, *A. fasciculatus* has been responsible for damage to cocoa beans and to various other stored products. The beetle is dark castaneous with numerous paler spots and a median longitudinal stripe of the same colour as the spots, from the head to the apex of the elytra. It measures approximately 3.5 mm. in length.

Control of *A. fasciculatus* is difficult, therefore it is highly important that all dead pods be collected and burned, to prevent them from becoming foci of infestation. Dried pods collected in the field and kept under observation in the laboratory have yielded a considerable number of other species of Coleoptera, namely *Laemophloeus* ? *fovicollis*, Gronv., and *Laemophloeus* sp. (CURCULIONIDAE), *Prometopia catilina*, Olliv. (NITIDULIDAE), *Lilargus exiguus*, Olliv. (MYCETOPHAGIDAE), *Othnius delusa*, Pasc. (OTHIIDAE), *Acicnemis dumalis*, Fst. (CURCULIONIDAE), *Litocerus* sp., *Phacocrotes pictus*, Jord., and *Tropideres securus*, Boh. (ANTHRIBIDAE), *Pterolophia melanura*, Pasc., and *Sybra* sp. (LAMIIDAE), *Hypothenemus arceae*, Horn, *Xyleborus similis*, Ferr., *X. torquatus*, Eich. (SCOLYTIDAE), *Hemicera splendens*, Wied. (TENERIONIDAE), and *Scyrmus* sp. (COCCINELLIDAE), the last named being most probably a predator of the larvae and adults of one or more of the other insects mentioned.

Hemicera splendens was found in pods in which decay was not very far advanced. The Lamiid, *Pterolophia melanura*, has been recorded damaging the thicker portions of the roots of *Derris* spp., and branches of mango in which die back had supervened. It is a moderately robust insect measuring 9-14 mm. in length. The antennae are black with a transverse median whitish castaneous stripe on the lower surface of segment 3 and with a trace of white on segments 4 and 8. The head and eyes are black. Derm black with irregular pale reddish and whitish pubescence. Legs

black, the femora and tibiae having small patches of pale rufous pubescence. Elytra with a median, transverse, somewhat indefinite broad stripe of whitish pubescence.

The larva is whitish with the anterior part of the head and the mandibles piceous, the base of the head is testaceous. Head and body moderately setose. When full-grown, the larva is about 14 mm. long. The pupa is whitish and has certain areas covered with setigerous tubercles which are arranged as follows—a few on the nota; segments 1-4 of the abdomen dorsally with two rows with the apices directed posteriorly; segments 5-7 with two rows, the apices of those in the basal row directed posteriorly and of those in the apical row directed anteriorly; segment 8 with a tubercle dorso-laterally and segment 9 with a few tubercles along the basal margin laterally. The tubercles on the dorsum of the abdomen are mucronate and in some cases could more accurately be termed spines. On the femora, near the apex, externally, is a group of robust setae. No information is available regarding the duration of the larval stage, but it has been ascertained that that of the pupal stage is 9-10 days.

From unripe pods, the Lepidoptera, *Eilema vicaria*, Walk. (ARCTIIDAE), *Dichrocrois punctiferalis*, Guen., *Hyphantidium albicostalis*, Walk. (PYRALIDAE) and *Pyroderces philodella*, Meyr. (COSMOPTERYGIDAE), were obtained.

D. punctiferalis has also been recorded from seeds of rambutan and of castor (*Ricinus communis*), and *P. philodella* from the male flowers of areca palm (*Areca catechu*), berries of coffee, decaying flowers of coconut (*Cocos nucifera*), seeds of cotton, and from lac. These Lepidoptera have been included in the category of secondary pests, but it may not be entirely accurate to consider them as such. It is probable, however, that entirely healthy pods are not attacked by them.

The adult of *D. punctiferalis* is pale ochreous with numerous small black spots, and measures 22 mm. across the outstretched wings. Its larva has a black head, the prothoracic shield piceous, and the body pale greenish with a pinkish suffusion dorsally. To some extent the colour is affected by that of the ingested food, which may be greenish or pale red according to the part of the pod on which the larva has been feeding. The meso- and metathoracic segments have four dorsal and five lateral, the abdominal segments four dorsal and three lateral, raised fuliginous areas with one or two setae arising from them. When full-grown, the larva measures approximately 20 mm. in length. Throughout its life it lives in concealment under a cover of silk and grass in or on a pod (Plate I).

Other insects found in decaying pods are a Capsid of a genus probably allied to *Fulvius* and an Anthocorid, *Lasiophilus* sp., both of which (the last mentioned almost certainly) prey on other insects in the pods. Some of the insects found, with the exception of the Capsid, were observed to have numerous mites (LAELAPIDAE) on them.

A Forficulid, *Spongovostox semiflava*, Burm., and a Dipteron, *Telostylinus lineolatus*, Wied., have also been bred from decaying pods, both the larvae and adults of the former most probably feeding on rotting tissues, but it is not unlikely that they, in common with certain other members of the FORFICULIDAE, are predacious on other insects and their larvae living in the decaying pods.

The larvae of *T. lineolatus* are frequently met with in various decaying fruits to which the adults are attracted, both for the purpose of obtaining food and for oviposition.

7. Historical Account of *Helopeltis* spp.

The genus *Helopeltis* was erected in 1858 by Signoret (Ann. Soc. Ent. Fr. (3), 6, p. 502) to receive the species *antonii* recorded from Ceylon and Burma and which has since been reported as a pest of tea in Java.

In 1871, Stål described two more species—*pellucida* and *collaris* (Oef. Vet. Ak. **27**, p. 657) from the Philippine Islands, and in 1873 two species, namely *niger* and *braconiformis* (= *Dulichius clavifer*, Walk.) were described by Walker, the former from Waigiou and the latter from New Guinea.

Waterhouse, in 1886, added two more species, *bradyi* and *theivora*, from Java and Assam respectively (Trans. Ent. Soc. Lond. p. 458) and in 1888 another species—*romundei*—from Java (Trans. Ent. Soc. Lond.). *H. febriculosa*, which is most probably a synonym of *H. theivora*, was described by Bergroth in 1889 (Ent. Month. Mag. **25**, p. 271). In 1892, Reuter described the species *bergrothi* from Gaboon (Ent. Month. Mag. **28**, p. 159), and in 1903 Distant described the species *cuneata* from Nawngchik (Fasc. Malay. Zool. **1**, p. 270, pl. XVI) and in 1904 the species *oryx* from Ceylon (Fauna Brit. Ind. Rhynch. **2**, p. 441).

Two years later the number of species was increased by Reuter with *schoutedeni* from the Congo (Ent. Mag. Lond. **42**) and *alluaudi* also from Africa (Oef. Vet. Soc. **47**). The next new species was *cinchonae* from Bhutan, described by Mann (Mem. Dept. Agric. Pusa, Ent. Ser. **1**, 1907), which has since been recorded from Malaya and Java. A species from Australia, the first to be recorded from that continent, was described by Kirkaldy as *australasiae*, from New South Wales in 1908 (Proc. Linn. Soc. N.S.W.). A new variety of *bergrothi* (*disciger*) and another new species *rubrinervis* were described by Poppius in 1910 (Kilimandjaro—Meru Exped. **12**, p. 4) and also *plebejus*, *sanguineus* and *labaumei* (Rev. Zool. Afr. **1**, p. 194), all from Africa.

An African and a Javan species—*bergevini* and *elegans* respectively—were determined as new by Poppius in 1914 (Tijdschr. Ent. **56** suppl.) and the same author in 1915 described three new species discovered in the Philippine Islands—*bakeri*, *obscuratus* and *pallidiceps* (Phil. Journ. Sci. **10**), also three from Formosa—*fasciaticollis*, *pallidus* and *brevicornis* (Arch. Naturges. **80**). A new species found in Sumatra was described by Roepke in 1916 (Tijdschr. Ent. **59**) as *sumatranus*, and additional African species and varieties, namely *lemosi* from San Thomé, *maynei*, *maynei* var. *intermedia*, and varieties of *bergrothi* (*flavescens*, *nigripes*, *mayumbensis*) and of *sanguineus* (*rubra* and *vanderysti*) from the Congo, were added to the list by Ghesquière (Rev. Zool. Afr. **10**) in 1922. *H. theobromae*, the new species discussed in the present paper, was described by the writer in 1939¹².

The majority of the species referred to are probably true species, but in recent years, doubt has been expressed whether *bradyi*, *antonii*, *romundei*, as well as *cinchonae* and *brevicornis*, are distinct species or varieties. Further investigations into the life-histories of *Helopeltis* and examinations of the male genitalia may prove that other closely related forms have been accorded specific rank when, in fact, they are merely varieties.

Helopeltis generally, are fragile insects, and soon after death change considerably in colour. They also undergo a certain degree of distortion during desiccation, affecting particularly the scutellar spine and the abdomen, the apex of the former collapsing so that the apical club becomes flat on the upper surface.

It is obvious that it is not always practicable to draft figures and draw up descriptions of insects on the spot, but if this were done, particularly when insects in which the colour is unstable and the integument delicate are being studied, difficulties and confusion in determinations would, it is believed, be greatly lessened.

Regarding the nomenclature of this genus, attention is drawn to the fact that certain authors have overlooked that a specific name of *Helopeltis* should have a feminine termination.

8. Host-plants of *Helopeltis*.

Helopeltis spp. are able to thrive on a large number of plants of various families, a circumstance which is clearly an important obstacle to control measures, since it is

rarely, if ever, possible or practicable to remove and destroy all alternative host-plants growing in the neighbourhood of the crop that it is desired to protect. Knowledge of alternative host-plants, nevertheless, is useful, in that it may assist in the detection of foci of infestation of a newly planted area or of plants which have recently come into bearing.

Of the 33 species and 7 varieties of *Helopeltis* referred to in the present paper, not all are of great economic importance. It has therefore been considered adequate to publish a list of the host-plants of those species which are undoubtedly pests of crops.

The three most important plants attacked are tea, cocoa, and cinchona, the damage to tea being probably the most serious, since the young leaves and shoots, the parts selected for the manufacture of tea, are principally affected.

H. antonii and *H. theivora*.—Tea, mango, avocado pear, cocoa, *Cinchona* spp., kapok, pepper (*Piper nigrum*), cinnamon (*Cinnamomum zeylanicum*), camphor (*Cinnamomum camphora*), *Ficus elastica*, jak fruit, tamarind (*Tamarindus indica*), guava (*Psidium guyava*), *Inocarpus edulis*, rambutan, *Heliotropa* sp., *Fuchsia* sp., rose, *Chrysanthemum* sp., *Phalaenopsis amabilis*, *Gardenia grandiflora*, *Bauhinia variegata*, *Solanum grandiflorum*, *Eucalyptus* sp., *Capsicum* sp., annatto, *Datura alba*, *Melastoma malabathricum*, *Eryngium foetidum*, *Stachytarpheta indica*, *Solanum* sp., *Villebrunea* sp., *Saurauja* sp., *Tephrosia candida*, *T. vogelii*, *Melia azadirachta*, and mahogany.

H. sumatranus.—Tea, gambier (*Uncaria gambir*).

H. bergrothi.—Tea, *Strophanthus gratus*, *Cryptostegia madagascariensis*, *Acalypha* sp., *Bixa* sp., *Aralia* sp., avocado pear.

H. maynei.—Cotton.

H. lemosi.—Cocoa, guava, mango, *Aralia* sp., avocado pear, cassava (*Manihot utilisima*).

H. bergevini.—Cocoa.

H. cuneata.—Araceae (possibly exclusively).

H. sanguineus.—Cocoa.

H. bradyi.—Tea, cinchona.

H. cinchonae.—Tea, cinchona, *Azalea scabra*, *Oenothera* sp., *Cymbidium* spp., *Gymnura omphaloides*.

H. theobromae.—Cocoa, annatto, guava, *Muntingia calabura*.

For the records of host-plants of *H. antonii* and *H. theivora* in the foregoing list the writer has referred mainly to an extremely excellent paper by Dr. W. Roepke³.

Recent investigations in Malaya by the writer have revealed three other possible host-plants of *H. bradyi* and *H. cinchonae*, namely *Dioscorea* sp., *Oxalis* sp. and another plant which has been named tentatively *Cephaelis angustifolia*. The *Dioscorea* and *Cephaelis*, which were growing among low bushes in a wooded ravine in a tea plantation, and the *Oxalis* as a cover among tea bushes, were observed to exhibit signs of *Helopeltis* attack.

The question of the control of *Helopeltis* spp. by means of trap crops occasionally comes to the fore, but when the relatively large number of alternative host-plants is examined, it should be realized that the selection of one plant in particular to serve the purpose of attracting the insects away from the plant it is desired to protect, is impossible to make, unless extensive tests to show the relative palatability of known host-plants to *Helopeltis* are made.

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EXPLANATION OF PLATE II.

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|------|-----|---------------------------------|------------------------|
| Fig. | 1. | <i>Helopeltis theobromae</i> , | Miller |
| „ | 2. | „ | „ 1st instar larva |
| „ | 3. | „ | „ 5th „ „ |
| „ | 4. | „ | „ ovum |
| „ | 5. | <i>Gampsocoris pulchellus</i> , | Dall. |
| „ | 6. | „ | „ ovum |
| „ | 7. | „ | „ 5th instar larva |
| „ | 8. | <i>Helopeltis bradyi</i> , | Waterh. |
| „ | 9. | „ | „ head and pronotum, ♀ |
| „ | 10. | <i>Helopeltis sumatranus</i> , | Roepke |
| „ | 11. | <i>Helopeltis cinchonae</i> , | Mann |



NEW SPECIES OF EUPLECTRINI (HYM. CHALCIDOIDEA) FROM EUROPE, AFRICA AND ASIA.

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Among the large family of the EULOPHIDAE (Chalcidoidea), the EUPLECTRINI are closely related to the ELACHERTINI and form with them the subfamily ELACHERTINAE. In common with the genus *Elachertus*, Spin., they have antennae with a 4-jointed funicle, complete parapsidal furrows, often longitudinal furrows on the scutellum and a petiolated abdomen. They are, however, easily distinguished by the large size of the spurs of the hind tibiae, the longest being generally more or less as long as the first two tarsal joints together.

The great uniformity in their structure makes their study difficult, and only one genus had been recognised until Girault described in 1913 two other genera from Australia, one of which is doubtful.

We have been able to study a large number of species, some of which have been found in the collections of the British Museum, mostly among the unnamed specimens collected by R. E. Turner in South Africa, while many other species have been received by the Imperial Institute of Entomology; most of these, bred from various noxious pests, may be of great economic importance.

During the study of this large material, in which 49 species have been distinguished, I found it convenient to divide them into groups, some of which are here described as new genera. The state of war has not allowed me to complete this study as I should have liked; many of the species already described from Asia could not be recognised through their mostly short descriptions, and being unable in the present time to inquire about types or co-types, it has not been possible to incorporate them in our keys. One or more of our species will perhaps be found later to be synonyms of some of these species. Our attempt to find good characters to distinguish the different species will, we hope, encourage other students to complete our studies and to establish these synonyms. We shall give in an appendix to this paper the original descriptions of all Asiatic species which we were unable to recognise.

The EUPLECTRINI are all parasites of larvae of Lepidoptera and their life-history is specially interesting. The *Euplectrus* species are among the very rare parasitic Hymenoptera which live as ectoparasites on free-living hosts. They are also the only Chalcids known to enclose their pupae in a cocoon.

The female *Euplectrus* lays its eggs, generally in small groups, on the back of half-grown to almost fully-grown caterpillars. The eggs are fixed firmly in the integument of the host, but rest on it over the site of the puncture. The young larvae remain fixed to the egg-capsule and begin to suck the caterpillar while this is still moving about. The parasitic larvae never change their place of feeding and form, when larger, a compact mass over the back of the caterpillar. When full-grown their host dies and they begin to crawl towards the sides of the host larva and to secrete some fibres fixing the host to the support; then they pass to the underside of the dead host and each parasite larva encloses itself in a rough imperfect cocoon. It has been found that the secretion of the "silk" is made through the anus and that it comes from the modified Malpighian tubes. The parasite pupae lie thus under the dried body of their host, fixed on the support by their back, as in other Eulophid genera, especially *Comedo* spp. The adult *Euplectrus* emerges by finding a way through the fibres of its cocoon. The number of parasites feeding

on one caterpillar is very variable, even in the same species, and may range from 1 to about 60. The period necessary for the development must vary greatly with the species and the climate. In the species which have been studied it is 4-7 days for the larval period, 2-3 days for the prepupal period and 4-12 days for the pupal period, so that the total length of life is generally 15-21 days. For more detailed accounts of the biology of *Euplectrus*, I refer to the following four main publications: R. C. Smith, Observations on *Euplectrus platyhypenae* How., a parasite of Noctuid larvae (Bull. Brooklyn Ent. Soc., **22**, 1927, pp. 128-134); M. Thomsen, Some observations on the biology and anatomy of a cocoon-making Chalcid larva, *Euplectrus bicolor* Swed. (Vidensk. Medd. Nat. For. Kjob., **84**, 1927, pp. 73-89); H. Bishoff, Zur Biologie des *Euplectrus bicolor* Swed. (Zeitschr. f. wiss. Ins., **24**, 1929, pp. 78-82); N. S. Noble, *Euplectrus agaristae* Crawford, a parasite of the Grape-vine moth, *Phalaenoides glycinae* Low. (Jour. Austr. Inst. Agric. Sci., **2**, 1936, pp. 165-168).

Key to the Genera of EUPLECTRINI.

1. Propodeum with two longitudinal carinae, enclosing a median area; pronotum carinated; eyes strongly ciliate; body generally yellow...*Neoplectrus*, Ferr.
Propodeum with only one median carina.....2
2. Spurs of hind tibiae not longer than the metatarsus; pronotum almost rectangular, distinctly carinated; propodeum with median carina and distinct lateral carinae; body yellow.....*Metaplectrus*, gen. nov.
Spurs of hind tibiae generally as long as, or slightly longer or shorter than the first two tarsal joints together; pronotum narrowed or rounded in front, if carinated then propodeum flat or with only one longitudinal carina.....3
3. Thorax almost flat above, mesonotum, scutellum, metanotum and propodeum about on the same horizontal level; body more or less yellow.....
Platyplectrus, gen. nov.
Thorax not flat above, the propodeum distinctly oblique.....4
4. Scutellum with two longitudinal furrows; body black or with yellow markings...
Euplectromorpha, Gir.
Scutellum without lateral furrows; body black, abdomen more or less yellow at base, legs generally entirely yellow.....*Euplectrus*, Swed.

Genus *Neoplectrus*, Ferrière.*

Key to the Species.

1. Median area of propodeum hexagonal, with transverse carinae (costulae) distinct.....*areolatus*, sp. n.
Median area less distinctly hexagonal, costulae absent.....2
2. Flagellar joints elongate, club not or scarcely broader than funicle; median tibiae of male entirely yellow.....*bicarinatus*, Ferr.
Flagellar joints shorter, 4th funicle joint subquadrate, club short, broader than funicle and broadly truncate; median tibiae of male black at tip.....*maculatus*, Ferr.

* Bull. Ent. Res. **31**, 1940, p. 134.

Neoplectrus areolatus, sp. nov.

♂♂. Body entirely yellow except the lines on the face and the transverse carina of the pronotum; anterior part of pronotum and transverse band before end of abdomen sometimes brownish.

Head transverse, vertex rather broad, with a few long black ciliae; lateral ocelli much closer to the front ocellus than to the eye-margins. Eyes short oval, strongly ciliate. Cheeks converging towards mouth. Antennae with the scape narrow, scarcely reaching to the front ocellus; pedicel not quite twice as long as broad; annellus very small; first funicle joint broader and about twice as long as the pedicel, the three following joints subequal in length, shorter than the first, but the 4th still longer than the pedicel; club as long as the first funicle joint. Pronotum large, carinated, covered with small black ciliae and with six longer ciliae along the posterior margin. Mesonotum transverse, parapsidal furrows deep. Scutellum almost flat, finely shagreened, with four long black ciliae. Propodeum with the median area distinctly hexagonal and with two closed areae on each side; spiracles short oval. Mesopleurae smooth. Wings hyaline, densely ciliate; marginal vein a little longer than the submarginal, costal cell narrow; stigmal vein short, forming a very acute angle with the postmarginal vein, which is almost three times as long as the stigmal. Front and median femora each with a long black cilium before tip, tibiae with a row of short ciliae; hind legs stronger, the longest tibial spur as long as half the metatarsus. Abdomen oval, narrower and shorter than the thorax; ovipositor very slightly protruding; abdomen of male still shorter, truncate behind.

Length, 1.2-1.8 mm.

CELEBES: Paloe, 2♀, 2♂, 11.ii.1936 (*R. Awibowo*), ex larva of *Orthocraspeda catenatus* (LIMACODIDAE). MALAY PENINSULA: Kuala Lumpur, 1♀, 8.xii.1936 (Agric. Dep. Entom. Div., n. 1460), ex larva of *Setora nitens* (LIMACODIDAE).

Neoplectrus bicarinatus, Ferrière 1940, Bull. Ent. Res., **31**, p. 134.

JAVA: ex larvae of *Artona catoxantha* (ZYGAENIDAE).

Neoplectrus maculatus, Ferrière, op. cit., p. 136.

JAVA: ex *Artona catoxantha*. CEYLON: ex *Natada nararia* (LIMACODIDAE).

Genus **Metaplectrus**, nov.

Body short, yellow, very similar in general aspect to *Neoplectrus*. Eyes ciliate. Pronotum distinctly margined in front, almost rectangular. Mesonotum short. Scutellum broad, with thin longitudinal furrows. Propodeum short, with distinct median and lateral carinae. Abdomen short, more or less rounded, shorter than the thorax. Spur of hind tibiae short, not or scarcely longer than the metatarsus.

Metaplectrus thoseae, sp. nov.

♀. Body orange-yellow; the following areas generally black: a small spot on occiput, the transverse carina of pronotum, a spot under the tegulae and the tip of abdomen. But two specimens, from Ceylon and Sumatra, are somewhat darker, and the following parts are also black: a large part of the occiput, the anterior region of the pronotum, a line at base of scutellum and spots on sides of metanotum and near spiracles of propodeum. Antennae always brown, scape and pedicel yellow. Legs light yellow.

Head transverse, vertex with long sparse black ciliae; ocelli in a low triangle, the lateral closer to the front ocellus than to the eye-margin. Eyes rounded, densely ciliate. Cheeks converging strongly towards the mouth. Antennae inserted slightly below the lower eye-level; scape narrow, not quite reaching to the front ocellus; pedicel about twice as long as broad; first funicle joint twice as long as the pedicel, the following joints shorter, about one and a half times as long as broad; club a little longer than the preceding joint. Pronotum as long as the mesonotum, strongly transversely carinated in front, finely rugulose and dull above, covered with short ciliae and with a row of longer ciliae behind; mesonotum transverse, slightly rugulose, the parapsidal furrows rather deep. Scutellum finely reticulose above, almost smooth on the sides, with distinct longitudinal furrows. Propodeum smooth and shining, with a median carina which fuses into a basal transverse carina, and lateral carinae which converge behind, forming two enclosed areae. Wings large; marginal vein about as long as the submarginal vein; stigmal vein as long as one-third of the marginal; postmarginal vein one and a half times as long as the stigmal. Abdomen short, rounded, pointed behind, about as long as half the length of the thorax; 2nd segment smooth, covering the greater part of the abdomen. Ovipositor not protruding.

♂. Unknown.

Length, 1.5–1.8 mm.

CEYLON: *Passara*, 6 ♀, v.1929, 2 ♀, vi.1929 (*Dr. J. C. Hutson*), ex larvae of *Thosea cervina*; 6 ♀, vi.1929 (*Dr. Hutson*), ex *Natada nararia*, young larvae only. SUMATRA: East Coast, Asahan, 1 ♀, 1934–36 (*F. Schneider*), ex larva of LIMACODIDAE on *Uscana gambir*.

Genus *Platyplectrus*, nov.

Thorax flat above, the mesonotum, scutellum, metanotum and propodeum being almost on the same level. Eyes not or only shortly ciliate. Pronotum large, margined or rounded in front. Scutellum with narrow longitudinal furrows. Propodeum with a strong median carina, elevated at base, where it forms often a translucent protuberance. Abdomen narrow, elongate, about as long as the thorax; petiole very short, transverse. Spurs of hind tibiae about as long as the first two tarsal joints together. Body yellow or black and yellow.

Genotype: *P. natadae*, sp. n.

Key to the Species.

1. Pronotum margined in front.....2
 Pronotum rounded in front, without transverse carina.....3
2. Body entirely orange-yellow; scutellum shagreened.....*orthocraspedae*, sp. n.
 Body with black markings on head, thorax and abdomen; scutellum smooth;
 size larger.....*natadae*, sp. n.
3. Abdomen with a black transverse band behind the middle; propodeum black
 in middle and black median stripes on mesonotum and scutellum; hind
 tarsi, at least the metatarsus, yellow.....*ornatus*, sp. n.
 Abdomen orange-yellow, only the sides slightly black; propodeum yellow along
 the middle; median stripes on mesonotum and only base of scutellum;
 hind tarsi black.....*capensis*, sp. n.

It is possible that *Euplectrus nigromaculatus*, Ashmead, and *Euplectrus flavescens*, Crawford, belong to this group (see Appendix).

Platyplectrus natadae, sp. nov.

♂♂. Body yellow, with the following parts black: stemmaticum, margins of frontal furrow, spot on occiput, pronotum in front and back, spots on parapsides and axillae, median stripe on scutellum, more or less distinct, sides of axillae and metanotum, the entire propodeum, spots on basal sides of abdomen and about posterior half of abdomen, spot on mesosternum and more or less distinct lines on hind coxae and femora. Some of these black parts are sometimes reddish-brown or bordered by that colour. In the male the black portions are often larger and may cover the entire frons, pronotum and mesonotum. Antennae brown, the scape yellowish below.

♀. Head very transverse. Ocelli small, the lateral closer to the front ocellus than to the eye margins. Eyes oval, densely ciliate. Vertex covered with not very long ciliae. Antennae inserted below the middle of the face; scape narrow, not reaching to the front ocellus; pedicel short, scarcely longer than broad; first funicle joint elongate, almost three times as long as the pedicel and distinctly longer than the following joints, which are about one and a half times as long as broad; club short oval. Pronotum large, as long as the mesonotum, margined in front, with irregular transverse striation and covered with short white ciliae, with six longer ciliae along hind margin. Mesonotum finely rugulose, dull; parapsidal furrows deep. Scutellum smooth and shining, flat, broadening and truncate behind, with longitudinal furrows. Propodeum horizontal, smooth, narrowed behind, with a strong median carina, surmounted at base by a translucent, tongue-like protuberance; lateral carinae distinct; spiracles large, oval. Wings large; marginal vein longer than the submarginal; stigmal vein narrow; postmarginal vein twice as long as the stigmal. Hind legs strong; the longest tibial spur as long as the two first tarsal joints together. Abdomen elongate, pointed behind, narrower and shorter than the thorax; petiole short, subquadrate; ovipositor scarcely protruding.

♂. Similar, smaller; abdomen narrow, broadening towards tip, where it is truncate or shortly rounded.

Length, ♀ 2.4–2.8 mm.; ♂ 1.8–2.2 mm.

CEYLON: Talawakelle, 7 ♀ 4 ♂, vi.1935; 1 ♀ 4 ♂, ix.1931 (*C. B. R. King*), ex *Natada nararia*, Moore.

Platyplectrus orthocraspedae, sp. nov.

♀♂. Body entirely yellow; flagellum of antennae more or less brownish.

♀. Head transverse; vertex with some black scattered ciliae; ocelli small, the lateral a little closer to the front ocellus than to the eye-margin; eyes rounded. Antennae with the scape short, ending far below the level of the ocelli; pedicel very short, almost rounded; first funicle joint elongate, about three times as long as the pedicel; the following joints somewhat shorter, but the 4th still twice as long as broad; club a little longer than the preceding joint. Pronotum large, finely transversely striate, with a transverse carina in front. Mesonotum slightly longer than the pronotum, the parapsidal furrows rather deep. Scutellum shagreened, flat, about as long as broad, with more or less distinct longitudinal furrows. Propodeum horizontal, almost on the same level as the scutellum; median carina strong, ending in front in a translucent, rounded lamina; lateral carinae slightly curved, reaching behind in transverse furrows. Wings densely ciliate; marginal vein a little longer than the submarginal; stigmal vein very oblique, shorter than the postmarginal. Front and median femora each with a long cilia before the tip; hind femora thickened, with a row of long ciliae below; tibial spur as long as two tarsal joints together. Abdomen about as long as the thorax, pointed behind.

♂. Similar; funicle joints more elongate, the first four times as long as the pedicel, which is small and rounded; abdomen oval, shorter than the thorax.

Length, ♀ 1.7–2 mm. ; ♂ 1.4–1.6 mm.

JAVA : Serang, 2 ♀ 5 ♂, x.1936 (*R. Awibowo*), ex *Orthocraspeda trima*, larva ; Buitenzorg, 1 ♂ (on slide), 4.viii.1921 (*R. Menzel*), ex *Setora nitens*. CELEBES : Paloe, 1 ♀, xi.1936 (*R. Awibowo*), ex *Orthocraspeda catenata*.

***Platyplectrus ornatus*, sp. nov.**

♀. Body yellow, with the following parts black : frontal furrow behind the scapes, curved line before ocelli, occiput, pronotum in front and on the sides, median longitudinal stripe on the mesonotum, spots on the parapsides, narrow incomplete median stripe on the scutellum, sides of axillae and metanotum, propodeum except on sides, petiole, sides of abdomen and broad transverse band before the end. Antennae brown above, scape and pedicel entirely yellow ; legs yellow with only a small black spot on the hind coxae.

Head narrow ; vertex and eyes less densely striate than in *P. natadae*. Ocelli small ; eyes almost rounded. Scape short, not reaching to the ocelli ; pedicel scarcely longer than broad ; the first funicle joint twice as long as broad, longer than the three following joints ; club somewhat longer than the preceding joint but shorter than the first funicle joint. Pronotum large, margined in front, transversely striate, covered with white ciliae. Mesonotum a little longer than the pronotum, shagreened ; parapsidal furrows deep in front. Scutellum shagreened, a little broadened and rounded behind. Propodeum almost horizontal, with a median carina and a tongue-like lamina at base ; lateral carinae not very distinct, ending behind in deep furrows ; spiracles large oval. Marginal vein longer than the submarginal, about four times as long as the stigmal and twice as long as the postmarginal vein. Hind tibial spur as long as the first two tarsal joints together. Abdomen oval, pointed behind, narrower but not much shorter than the thorax ; petiole very short.

One ♂ which belongs probably to this species is very similar to the female and has the same coloration, except that the abdomen is black only on the posterior third, the hind coxae are entirely black and the antennae are entirely orange-yellow. Antennae with pedicel almost rounded, first funicle joint twice as long as broad, longer than the following joints. Abdomen elongate, narrower and shorter than the thorax.

Length, ♀ 2.5–2.9 mm. ; ♂ 2 mm.

TANGANYIKA : Burka Plantation, Arusha, 1 ♀, viii.1932 (*A. H. Ritchie*), ex larva of *Niphadolepis alianta*, Karsch, on *Coffea arabica*. SOUTH AFRICA : Cape Prov., Mossel Bay, 2 ♀, vii & xi, 1921 ; Pondoland, Port St. John, 2 ♀, vi.1923, 1 ♂, iii.1924 (*R. E. Turner*), hosts unknown.

***Platyplectrus capensis*, sp. nov.**

♀. Body yellow with the following parts black : frons before the ocelli, occiput, pronotum in front and on the sides, partly also in the middle, a median stripe along the mesonotum, narrower behind, a broad stripe on the sides of the parapsides, a short median marking at base of scutellum, part of the pleurae, lines on sides of propodeum and of abdomen near base. Antennae black, scape yellow at base and below ; legs yellow, hind coxae black except at tip.

Head very transverse ; ocelli small, close together ; eyes short, oval, scarcely ciliate. Scape short, pedicel scarcely longer than broad ; first funicle joint about as long as and broader than the scape, the following joints shorter, but all longer than broad. Pronotum large, rounded in front, transversely rugulose. Mesonotum shagreened, parapsidal furrows deep at base. Scutellum flat with narrow lateral furrows which converge behind along the hind margin ; centre of scutellum irregularly striate, sides smooth. Propodeum smooth, median carina elevated at base in a

short translucent lamina. Marginal vein a little longer than the submarginal, about four times as long as the stigmal and twice as long as the postmarginal vein. Hind tibial spur as long as first two tarsal joints together. Abdomen elongate, narrower but almost as long as the thorax; ovipositor slightly protruding.

The male which we place here differs from that of *P. ornatus* in the following characters: pronotum with only a black spot in front and the hind margin black, parapsides entirely yellow, median stripe on mesonotum narrow, on scutellum broadening behind but incomplete, propodeum yellow in the middle, with black stripes on the sides, abdomen more broadly black at tip, hind coxae entirely yellow. Joints 2 to 4 of funicle short, subquadrate.

Length, ♀ 3 mm.; ♂ 1.7 mm.

SOUTH AFRICA: Cape Province, Mossel Bay, 1 ♀, xi.1921; Swellendam, 1 ♂, ii.1932 (*R. E. Turner*), host unknown.

Genus *Euplectromorpha*, Girault.*

Key to the Species.

1. Head and thorax partly yellow, at least the inner margins of the eyes yellow.....2
Head and thorax entirely black.....5
2. Thorax mostly yellow, at least the hind margins of pronotum and mesonotum and the sides of scutellum yellow.....3
Thorax mostly black, only the tip of pronotum and sides of scutellum more or less narrowly yellow.....4
3. Head with frons and vertex dark, margins of eyes broadly yellow; body black and yellow.....7. *variegata*, sp. n.
Head entirely black, only margins of eyes narrowly yellow; body orange-yellow.....8. *ausensis*, sp. n.
4. Scutellum shagreened in the middle or more or less transversely striate; hind margin of pronotum (except middle and sides of scutellum) yellowish.....9. *kiambuensis*, sp. n.
Scutellum rugulose or reticulate in the middle; hind margin of pronotum entirely yellowish.....10. *kampalana*, sp. n.
5. Abdominal petiole short, broader than long or subquadrate, or very small and narrow; scutellum shagreened or punctate, lateral furrows distinct, often crenulate, ending in a transverse furrow along the hind margin.....6
Abdominal petiole large, longer than broad, if subquadrate then scutellum finely shagreened or almost smooth and without furrow along the hind margin.....10
6. Pronotum margined in front.....7
Pronotum rounded in front, without carina.....8
7. Scutellum shagreened, slightly convex; lateral furrows distinct, more or less crenulated.....2. *artona*, Ferr.
Scutellum densely punctate, almost flat; lateral furrows narrower and not crenulated.....3. *malayensis*, sp. n.

* Mem. Queensl. Mus. 3, 1913, p. 280.

8. Head with dark green reflection ; funicle joints longer than broad ; scutellum shagreened, lateral furrows distinct, the transverse furrow crenulated.....
11. *nitidiceps*, sp. n.
Head black ; funicle joints subquadrate, except sometimes the first.....9
9. Scutellum strongly punctate, lateral furrows broad, crenulated ; eyes scarcely ciliate ; vertex smooth ; hind femora mostly dark.....12. *obscurata*, sp. n.
Scutellum transversely striate, lateral furrows narrower, not crenulated ; eyes ciliate ; vertex shagreened ; hind femora mostly yellow...13. *striolata*, sp. n.
10. Scutellum rugulose, lateral furrows and transverse furrow distinct and broad...11
Scutellum shagreened or smooth, lateral furrows narrow, transverse furrow scarcely visible.....12
11. Scutellum rugulose-areolate, furrows broad and crenulated ; funicle joints short, the fourth subquadrate.....4. *bussyi*, Crawford.
Scutellum rugulose-punctate, furrows narrower and not or slightly crenulated ; funicle joints all longer than broad.....5. *karnyi*, sp. n.
12. Funicle joints very short, joints 2 to 4 broader than long ; petiole subquadrate ; scutellum finely shagreened, smooth at tip.....14. *brevicornis*, sp. n.
Funicle joints longer than broad, except sometimes the fourth ; petiole more elongate ; scutellum almost smooth.....13
13. Pronotum rounded in front, without carina.....14
Pronotum margined in front.....15. *laeviscuta*, Thoms.
14. Head with dark green reflection ; last funicle joint subquadrate.....
1. *viridiceps*, Ferr.
Head black ; all funicle joints longer than broad.....6. *salomonis*, sp. n.

Asiatic Species.

1. ***Euplectromorpha viridiceps***, Ferrière 1940, Bull. Ent. Res., **31**, p. 136.

JAVA, ex *Artona catoxantha*. MALAYA, ex *Artona catoxantha*. INDIA : United Provinces, ex *Dasychira* sp. on *Tectona*.

2. ***Euplectromorpha artonae***, Ferrière 1940, loc. cit.

JAVA, ex *Artona catoxantha*.

3. ***Euplectromorpha malayensis***, sp. n.

♂. Head and thorax black ; abdomen also black or slightly reddish at base above. Antennae brown, scape yellow. Legs yellowish, all coxae black, the front coxae yellow at tip ; hind femora slightly brownish above.

♀. Head transverse ; lateral ocelli closer to the front ocellus than to the eye-margins ; from in front the head is a little broader than long, the cheeks shorter than the diameter of an eye ; face smooth. Antennae with the scape narrow, not reaching to the front ocellus ; pedicel very short, scarcely longer than broad, all funicle joints 1.5 to 2 times as long as broad ; club not or scarcely longer than the preceding joint. Pronotum large, almost rectangular, with a strong transverse carina in front. Mesonotum finely rugulose, dull. Scutellum densely and finely punctate ; the lateral furrows narrow but distinct, the transverse furrow along the hind margin punctate. Propodeum large, triangular, smooth ; median carina strong.

Wings large, marginal vein shorter than the submarginal; costal cell rather large; stigmal vein short; postmarginal vein more than twice as long as the stigmal vein. Hind legs strong, the longest spur of the hind tibiae as long as the first two tarsal joints together. Abdomen short oval, much shorter than the thorax, the petiole very short, transverse, partly hidden by the tip of the propodeum.

♂. Similar; antennae narrower with the funicle joints more elongate; abdomen narrower and almost as long as the thorax.

Length, ♀♂ 1.8-2.4 mm.

MALAYA: Kuala Lumpur, 4 ♀, iii.1932 (*G. H. Corbett*), ex larva of LIMACODIDAE on *Cinnamomum zeylanicum*; Ulu Sali Rd., 2 ♀, ix.1935 (*G. H. Corbett*), ex larva of *Setora nitens*; Banting, 1 ♀, ii.1936 (*G. H. Corbett*), ex *Parasa lepida*. JAVA: Garoem, 14 ♀ 4 ♂, ix.1922 (*H. Karny*), ex *Thosea* sp.

4. *Euplectromorpha bussyi*, Crawford 1911, Proc. U.S. Nat. Mus., 41, p. 279.

This species may be easily recognised by the peculiar structure of the scutellum, which is coarsely rugulose-reticulated with broad and crenulated furrows on sides and along the hind margin. The body is rather small, black, the abdomen whitish above in the middle and below, the legs yellow, with the hind coxae and hind femora above blackish. Propodeum smooth, rather large, triangular; abdominal petiole slightly longer than broad, the rest of the abdomen shorter than the thorax. All the rest agrees exactly with Crawford's description.

MALAYA: Setapak, 2 ♀, vii.1924 (*G. H. Corbett*), ex unknown larva (No. 1434). The type specimens were from Sumatra.

5. *Euplectromorpha karnyi*, sp. n.

♂. Black; abdomen yellowish above in the middle and below at base; antennae brown, scape and pedicel yellow; legs yellow, hind coxae black, hind femora brownish above.

Head very transverse; eyes rounded; lateral ocelli much closer to the front ocellus than to the eye-margins. Face very finely shagreened, with few scattered ciliae and a narrow furrow between the front ocellus and the base of the antennae. Scape short, slightly thickened; pedicel shorter and narrower than the first funicle joint, which is not quite twice as long as broad; following joints a little shorter than the first; club pointed at tip, longer than the preceding joint. Pronotum short, transverse, finely carinated in front. Mesonotum rugulose in the middle, smoother on the parapsides. Scutellum irregularly coarsely punctate, the lateral and posterior furrows distinct but only faintly carinated. Propodeum long, triangular, almost smooth, the median carina narrow and not reaching quite to the tip. Wings large, marginal vein a little longer than the submarginal and about three times as long as the stigmal. Hind legs strong, the longest tibial spur as long as the first two tarsal joints together. Abdomen narrower than the thorax; the petiole elongate, almost three times as long as broad.

Length, 2 mm.

JAVA: Tjibodas, 1,400 m., 1 ♂, 1923 (*H. Karny*), host unknown.

Papuan Species.

6. *Euplectromorpha salomonis*, sp. n.

♀. Head and thorax black, abdomen whitish below and on the basal half above. Antennae brown, scape and pedicel yellow; legs whitish, only the hind coxae black.

Head transverse ; eyes rounded ; lateral ocelli almost as far from the front ocellus as from the eye-margins ; frons almost smooth, with a narrow furrow between the front ocelli and the base of the antennae. Scape short ; pedicel scarcely longer than broad ; first funicle joint elongate, about three times as long as broad ; the following joints shorter, but all longer than broad ; club slightly longer than the preceding joint. Pronotum narrowed in front, not margined. Mesonotum finely shagreened. Scutellum smooth, lateral furrows narrow but distinct, not crenulated, converging slightly behind, but not ending in a transverse furrow. Propodeum smooth, elongate, triangular, with a narrow median carina. Wings large ; marginal vein about as long as the submarginal, stigmal vein short. Hind femora slightly thickened ; hind tibial spur not quite as long as the first two tarsal joints together. Abdomen narrower, but not much shorter than the thorax ; petiole a little longer than broad.

Length, 2 mm.

SOLOMON ISLANDS : Guadalcanal, 1 ♀, viii.1928 (*R. W. Paine*), ex *Zygaenid* feeding on ginger.

African Species.

7. *Euplectromorpha variegata*, sp. n.

♀♂. Body black or reddish-brown with the following parts yellow or orange-yellow : the face below the antennae and the cheeks, a stripe along the eyes, reaching to the vertex, two broad triangular spots on the pronotum, the sides and sometimes also the end of the mesonotum, the parapsides except sides, the sides of the scutellum more or less broadly, the postscutellum, the basal half of the abdomen, the scape entirely, pedicel and first funicle joints below, and the legs, except hind coxae and middle of hind femora. This coloration may vary ; the black parts are more or less broad, the face and cheeks may become brownish or even black, leaving only the margins of the eyes yellow, especially in the male ; on the thorax the yellow parts may be very small, but are always present on pronotum, mesonotum, axillae and scutellum.

Head very transverse, vertex margined behind the ocelli ; eyes oval ; lateral ocelli as far distant from the front ocellus as from the eye-margins ; cheeks converging strongly towards the mouth. Antennae inserted at the lowest level of the eyes ; scape short, not reaching to the front ocellus ; pedicel a little longer than broad ; first funicle joint longer than the pedicel, about twice as long as broad, the following joints not much longer than broad, the fourth subquadrate. Pronotum almost as long as the mesonotum, rounded in front, irregularly transversely striate. Mesonotum rugulose in the middle. Scutellum strongly shagreened to rugulose, lateral furrows distinct, ending in a transverse furrow along the hind margin. Propodeum smooth, triangular, with a strong median carina. Wings large ; marginal vein a little longer than the submarginal, postmarginal vein twice as long as the stigmal vein. Hind femora somewhat thickened ; hind tibial spur as long as the first two tarsal joints together. Abdomen oval, narrower and much shorter than the thorax.

♂. Similar, but generally darker ; abdomen very much shorter than the thorax, broadened behind, triangular.

Length, ♀♂ 1.7–2.5 mm.

SOUTH AFRICA : Cape Prov., Mossel Bay, 9 ♀ 10 ♂, vi–xii.1921 ; Pondoland, Port St. John, 1 ♀ 1 ♂, v.1923 (*R. E. Turner*), host unknown.

8. *Euplectromorpha ausensis*, sp. n.

This species, which is perhaps only a variety of *variegata*, may be distinguished mostly by the contrast between the reddish-brown and yellow body, with only a

spot on the mesonotum black, and the entirely black head, except the narrow yellow line along the inner margins of the eyes. On the thorax the hind margins of pronotum and mesonotum, the inner angle of the axillae and the sides of the scutellum are yellow.

Head, as seen from in front, broader than high; frons smooth. First funicle joint elongate, about twice as long as the pedicel; the three following joints slightly longer than broad. Form and structure of thorax and abdomen as in the preceding species.

Length, ♀ 2-2.8 mm.

S.W. AFRICA: Aus, 2 ♀, xi.1929 and i.1930 (R. E. Turner).

9. *Euplectromorpha kiambuensis*, sp. n.

♀. Black; only inner margins of eyes narrowly, hind margin of pronotum faintly, tegulae, sides of scutellum near end and basal half of abdomen yellow. Antennae brown, scape and pedicel yellow. Legs yellow, hind coxae and hind femora, except base and tip, dark brown.

Head very transverse; eyes shortly oval, ciliate; lateral ocelli at the same distance from the front ocellus as from the eye-margins. Antennae of type and co-types mostly broken. Pronotum large, rounded in front, not margined. Mesonotum not longer than the pronotum, finely rugulose. Scutellum with distinct lateral and posterior furrows, shagreened in the middle. Propodeum smooth, with distinct median carina. Abdomen narrower and shorter than the thorax. Wings and legs as in *variegatus*.

Length, ♀ 1.7-1.9 mm.

KENYA COLONY: Kiambu, 10 ♀, v.1930, 3 ♀, 1932 (R. H. LePelley), ex *Tortrix dinota*.

10. *Euplectromorpha kampalana*, sp. n.

♀♂. Black; inner margins of eyes narrowly, hind margin of pronotum slightly, tegulae, small spots on sides of scutellum and basal third of abdomen, yellow. Antennae brown, scape and pedicel yellow; legs yellow, all coxae and the middle and hind femora, except base and tip, brownish.

Very similar to *variegata*, but the eyes are not or scarcely ciliate and the sculpture of mesonotum and scutellum is more strongly rugulose. First funicle joint not much longer than the pedicel, the following joints all a little longer than broad. Scutellum with distinct lateral furrows, the posterior furrow slightly crenulated. Abdomen a little narrower and not much shorter than the thorax; petiole very short, scarcely visible.

Length, ♀ 2.1-2.3 mm.; ♂ 1.8 mm.

UGANDA: Kampala, 4 ♀ 1 ♂, ix.1927 (H. Hargreaves), host unknown.

11. *Euplectromorpha nitidiceps*, sp. n.

♀. Body black; head with dark green reflections; abdomen broadly brownish above. Antennae brown, scape yellow, pedicel blackish above. Legs orange-yellow, hind coxae black, tarsi brownish at tip.

Head transverse; lateral ocelli closer to the front ocellus than to the eye-margins; eyes short oval; vertex and face almost smooth. Antennae inserted above the clypeus; scape narrow not reaching to the front ocellus; pedicel slightly longer than broad; first funicle joint more than twice as long as broad, the following joints gradually shorter, the fourth not much longer than broad; club longer than the preceding joint. Pronotum rounded in front, not margined. Mesonotum shagreened,

with scattered ciliation and weak parapsidal furrows. Scutellum finely shagreened, almost smooth; lateral and posterior furrows narrow but distinct and slightly crenulated. Propodeum large, triangular, smooth, with a narrow median carina. Wings large; marginal vein about three times as long as the narrow stigmal vein; postmarginal vein twice as long as the stigmal. Hind legs strong, the longest tibial spur not quite as long as the first two tarsal joints together. Abdomen small, shorter and narrower than the thorax; petiole short, broader than long.

Length, 1.6-1.8 mm.

SOUTH AFRICA: Cape Prov., Ceres, 12 ♀, i-iii.1921; Mossel Bay, 3 ♀, ix-xii.1921; Swellendam, 1 ♀, ii.1932 (R. E. Turner), host unknown.

12. *Euplectromorpha obscurata*, sp. n.

♂♂. Body entirely black, except a short yellow ring near base of abdomen; antennae brown, lighter towards base, scape yellow; legs yellow, hind coxae black, hind femora more or less brown, broadly yellow at base and at tip. In the male the front and middle coxae are brownish and the hind femora are almost entirely dark brown, except at extreme base and tip.

♀. Head very transverse; ocelli rather large, the lateral at the same distance from the front ocellus as from the eye-margins; eyes short oval, not or scarcely ciliate. Vertex and face smooth. Antennae inserted near the clypeus; scape narrow, not reaching to the front ocellus; pedicel a little longer than broad; first funicle joint about twice as long as broad, the following joints shorter, slightly longer than broad or subquadrate. Pronotum rounded in front, not margined, irregularly transversely rugulose. Mesonotum roughly shagreened and with irregular transverse striation; parapsidal furrows shallow, especially behind. Scutellum closely punctate in the middle; lateral and posterior furrows broad, more or less distinctly margined and irregularly crenulated; axillae almost smooth. Propodeum large, triangular, finely punctate; median carina not sharp, with a narrow furrow on each side, interrupted here and there by irregular short transverse carinae. Wings large; marginal, stigmal and postmarginal veins in the proportion of 4:1:2. The longest tibial spur as long as the elongate metatarsus plus half the length of the following joint. Abdomen narrow, compressed, shorter and much narrower than the thorax; petiole very small and narrow, but slightly longer than broad.

♂. Similar but smaller; funicle joints, except the first, subquadrate. Abdomen short, triangular, smaller than the thorax.

Length, ♀ 2.2-3 mm.; ♂ 1.5-2 mm.

NYASALAND: Namiwawa, 14 ♀, 17.iv.1915 (C. Mason), ex larva of *Lymantriid* moth on cotton, 4 ♀, 20.iv.1915 (C. Mason), ex *Cacoecia occidentalis*. UGANDA: Luzira, 3 ♀, iii.1921 (H. Hargreaves), "from large galls on petiole of Kikokoma leaves." SOUTH AFRICA: Cape Prov., Mossel Bay, 16 ♀ 15 ♂, iv-x.1921, 1 ♂, ii.1922; Cape Town, Milnerton, 1 ♂, xii.1925 (R. E. Turner), host unknown.

13. *Euplectromorpha striolata*, sp. n.

♀. Black, abdomen yellow at base, more broadly below than above; antennae brown, scape yellow; legs yellow, hind coxae and an elongate spot on the upper part of hind femora blackish.

Head very transverse; lateral ocelli at about the same distance from the front ocellus as from the eye-margins; eyes short oval, distinctly and closely ciliate. Vertex and frons smooth with small scattered punctures. Antennae inserted above the clypeus; scape narrow and short, pedicel small, slightly longer than broad; first funicle joint about twice as long as broad, the following joints broader and subquadrate. Pronotum large, rounded in front, not marginate. Mesonotum

shorter than the pronotum, shagreened with scattered hair-punctures. Scutellum strongly transversely striate, the lateral and posterior furrows rather broad, smooth; axillae, sides of scutellum and propodeum smooth, the latter with a distinct median carina, higher at base. Wings large; marginal vein longer than the submarginal, costal cell rather broad; stigmal vein short; postmarginal vein twice as long as the stigmal. Hind legs strong, the longest tibial spur as long as the first and half the second tarsal joints; these two tarsal joints subequal in length. Abdomen small, depressed, short oval, a little narrower and much shorter than the thorax; petiole very small and short.

Length, 2 mm.

SOUTH AFRICA: Zululand, Eshowe, 1 ♀, v.1926 (R. E. Turner), host unknown.

14. *Euplectromorpha brevicornis*, sp. n.

♂♂. Black, abdomen with large yellow spot near base; antennae yellow to light brown, scape whitish; legs yellow, only hind coxae black, hind femora sometimes more or less brownish.

♀. Head transverse, vertex finely shagreened; lateral ocelli slightly closer to the front ocellus than to the eye-margins; eyes short oval, not ciliate. Antennae inserted above the clypeus; scape narrow and short; pedicel narrow, twice as long as broad and longer than the first funicle joint; flagellum short, first funicle joint subquadrate, the following joints broader than long, club as long as two preceding joints together; the whole flagellum with the pedicel is not longer than the height of the head. Pronotum short, with a fine, not very distinct, transverse carina; the narrow space between carina and hind margin smooth. Mesonotum closely reticulate in middle, finely shagreened at sides. Scutellum and axillae finely shagreened, almost smooth; lateral furrows narrow, straight, no furrow along hind margin. Propodeum large, smooth, median carina narrow. Abdomen depressed, rounded or short oval, much shorter than the thorax; petiole smooth, subquadrate or slightly longer than broad. Wings slightly yellowish; marginal vein about three times as long as the stigmal and twice as long as the postmarginal vein.

♂. Quite similar, smaller; antennal flagellum more ciliate; abdomen triangular, very small.

Length, ♀ 1.2-1.6 mm.; ♂ 1 mm.

SOUTH AFRICA: Cape Prov., Mossel Bay, 2 ♀, iv.1921; 8 ♀ 1 ♂, xi-xii.1921; 6 ♀, i-ii.1922 (R. E. Turner), host unknown.

European Species.

15. *Euplectromorpha laeviscuta*, Thomson 1878, Hym. Scand., 5, p. 188.

We have seen a female from Sweden, named by Ruschka, which agrees exactly with Thomson's description and belongs certainly to that species. The body is black with only a rounded yellow spot on the abdomen; the hind coxae are black and the hind femora dark brown above. Pronotum short and distinctly margined in front. Mesonotum closely reticulated in the middle, more shagreened on the sides. Scutellum entirely smooth, with narrow but distinct lateral furrows and no trace of a posterior furrow. Propodeum smooth, with a strong median carina. Abdomen oval, almost as broad as, but shorter than the thorax; petiole elongate, about three times as long as broad, smooth.

The presence of lateral furrows on the scutellum, mentioned also by Thomson, and the darkened hind coxae and femora, place this as the only palaearctic species in the genus *Euplectromorpha*.

Genus **Euplectrus**, Swed.*Key to the Species.*

1. Hind coxae and sometimes also hind femora black or brown.....2
Legs entirely yellow or orange-yellow.....3
2. Mesonotum finely striate with a median carina ; scutellum smooth ; only hind coxae brownish ; clypeus reddish.....1. *fulvicoxis*, sp. n.
Mesonotum reticulate, without median carina ; scutellum finely reticulate ; hind coxae and often femora blackish ; face entirely black...8. *fuscipes*, sp. n.
3. Abdominal petiole short, subquadrate or only slightly longer than broad.....4
Abdominal petiole about twice as long as broad.....28
4. Mesonotum irregularly transversely striate with a median carina generally complete, more rarely shortened in front.....5
Mesonotum reticulate, without median carina or rarely with a more or less shortened carina behind 14
5. Head entirely black, including the clypeus.....6
Face or clypeus yellow or reddish.....8
6. Abdomen yellow above and below, only black on the sides at base ; first funicle joint distinctly longer than the second ; (America).....—. *platyhypenae*, How.
Abdomen black at tip and on sides7
7. Scutellum almost smooth ; first funicle joint not longer than the second ; end of abdomen brownish.....23. *nigriceps*, sp. n.
Scutellum shagreened ; first funicle joint a little longer than second ; end of abdomen broadly black.....9. *nigrescens*, sp. n.
8. Face and cheeks yellow ; ocelli large, lateral ocelli closer to eye-margin than to front ocellus ; abdomen yellow with a transverse black stripe before the end...
2. *leucostomus*, Rohwer
Only the clypeus yellow or reddish.....9
9. Abdomen yellow above, only sides narrowly black.....10
Abdomen more or less black near or at tip.....11
10. Funicle joints elongate, all longer than the pedicel, the fourth at least twice as long as broad ; (Australia).....—. *agaristae*, Crawf.
Funicle joints shorter, the fourth little longer than broad and scarcely longer than the pedicel.....11. *ceresensis*, sp. n.
11. Abdomen yellow with a black cross-band before the tip and the sides slightly blackish.....12
Abdomen black at tip and on the sides.....13
12. Scutellum finely shagreened ; first funicle joint not much longer than the second
10. *cinctiventris*, sp. n.
Scutellum finely reticulate ; first funicle joint distinctly longer than the second...
25. *phthorimaeae*, sp. n.
13. Ocelli small, the lateral closer to the front ocellus than to the eye-margins ; scutellum finely striate, smooth at tip.....3. *indicus*, sp. n.
Ocelli larger, the lateral at the same distance from the front ocellus as from the eye-margins ; scutellum entirely finely striate.....24. *cacoeciae*, sp. n.
14. Face entirely black.....15
At least the clypeus yellow.....16

15. Funicle short, broadening at tip, the fourth joint, and sometimes also the third, subquadrate.....12. *turneri*, sp. n.
 Funicle more elongate and not or scarcely broadened at tip, all joints longer than broad.....13. *nigroclypeatus*, sp. n.
16. Only the clypeus yellow or reddish.....17
 Also face and cheeks mostly yellow.....22
17. Abdomen yellow at tip.....18
 Abdomen black at tip and on sides.....20
18. Abdomen yellow with a distinct transverse stripe before the end; lateral ocelli as far distant from the front ocellus as from the eye-margins; scutellum almost smooth4. *parvulus*, sp. n.
 Abdomen yellow above or with only a slight transverse stripe before tip; ocelli small, the lateral closer to the front ocellus than to the eye-margins; scutellum finely reticulate.....19
19. Mesonotum finely transversely striate, the median carina sometimes scarcely visible 11. *ceresensis*, sp. n.
 Mesonotum distinctly reticulate, without carina 14. *rufiventris*, sp. n.
20. Scutellum longitudinally striate; size relatively large; scape of male not much thickened22. *bicolor*, Swed.
 Scutellum finely shagreened or reticulate; size smaller.....21
21. Scape of male slightly thickened in the middle.....15. *epiplemae*, sp. n.
 Scape of male very thick.....16. *singularis*, sp. n.
22. Abdomen yellow at tip 23
 Abdomen black at tip.....26
23. Abdomen entirely yellow, only sides at base black.....24
 Abdomen with a transverse black stripe before tip.....25
24. Mesonotum finely rugulose; scutellum almost smooth, twice as long as the mesonotum; funicle joints 2 to 4 about twice as long as broad; head of male yellow 17. *aburiensis*, sp. n.
 Mesonotum more roughly rugulose; scutellum striate, not much longer than the mesonotum; funicle joints 2 to 4 little longer than broad.....
 5. *coimbatorensis*, sp. n.
25. Scutellum strongly striate; lateral ocelli as far distant from the front ocellus as from the eye-margins; pedicel distinctly shorter than the first funicle joint.....26. *liparidis*, sp. n.
 Scutellum finely shagreened; lateral ocelli closer to the front ocellus than to the eye-margins; pedicel scarcely longer than the first funicle joint.....
 18. *hargreavesi*, sp. n.
26. Hind tarsi short and thickened, the metatarsus two or three times as long as broad, joints 2 and 3 scarcely longer than broad, 4th joint very large, almost as long as the three preceding joints together; head of male yellow.....
 19. *brevitarsis*, sp. n.
 Hind tarsi normal, all joints distinctly longer than broad, 1st narrow, 4th not much longer than 2nd; head of male also mostly yellow.....27
27. Mesonotum distinctly reticulate; scutellum finely shagreened; funicle joints and pedicel subequal in length; cheeks almost entirely yellow.....
 20. *laphygmae*, sp. n.

- Mesonotum almost smooth, as is also the scutellum ; funicle joints more elongate, first longer than second and than the pedicel ; cheeks only yellow near the mouth.....21. *seychellensis*, sp. n.
28. Clypeus black like the rest of the head ; abdominal petiole shagreened.....
6. *ceylonensis*, Howard
- Clypeus yellow ; abdominal petiole smooth.....7. *petiolatus*, sp. n.

Asiatic Species.

1. *Euplectrus fulvicoxis*, sp. n.

♀. Black ; clypeus reddish-brown ; abdomen mostly yellowish above ; antennae brown, scape and pedicel yellow ; legs yellow, hind coxae dark brown, hind femora faintly darker beyond middle. Wings slightly infusate.

Vertex and frons smooth ; lateral ocelli closer to the front ocellus than to the eye-margins. Antennae inserted near the clypeus ; scape narrow, not reaching to the front ocellus ; pedicel small, a little longer than broad ; funicle joints broader than the pedicel, all longer than broad. Pronotum short, with a transverse carina just before the row of longer ciliae. Mesonotum finely transversely striate, with a distinct median carina. Scutellum and propodeum smooth. Marginal vein longer than the submarginal ; postmarginal vein twice as long as the narrow stigmal vein. The longest hind tibial spur as long as the first two tarsal joints together. Abdomen rounded, much smaller than the thorax ; petiole slightly striate, about one and a half times longer than broad.

Length, 1.8 mm.

JAVA : Tjibodas, 1,400 m., 1 ♀, 1923 (*H. Karny*), host unknown.

2. *Euplectrus leucostomus*, Rohwer 1921, Ann. Mag. Nat. Hist. (9) 7, p. 135.

♂♂. Black ; clypeus and face entirely yellow, as far as the margins of the eyes and a small area above the antennae. Abdomen yellow above, with only the sides and a more or less complete transverse band before the end brownish. Antennae yellow, slightly brownish at tip. Legs entirely yellow.

Head very transverse ; ocelli very large, the lateral ocelli closer to the eye-margins than to the front ocellus. Eyes large, not ciliate ; cheeks short. Scape narrow, reaching almost to the front ocellus ; pedicel longer than broad ; funicle joints elongate, the first more than twice as long as the pedicel, the fourth still twice as long as broad. Pronotum short. Mesonotum transversely striate and with a distinct median carina. Scutellum finely longitudinally striate. Propodeum smooth. Wings hyaline ; costal cell slightly broadened ; marginal vein almost four times as long as the stigmal and twice as long as the postmarginal vein. The longest hind tibial spur a little longer than the first two tarsal joints together. Abdomen short, oval, not much narrower but much shorter than the thorax ; petiole slightly broader than long.

Length, ♂♂ 1.5-2.5 mm.

Redescribed from the following specimens from SOUTH INDIA : Coimbatore, Forest of Maruda, 2 ♀, 18.ix.1929 (*T.K.U.*), ex larva of *Achaea* ; Coimbatore 1 ♂, 9.xi.1929 (*J.V.S.*), ex *Castor* Semilooper.

Three females from Kuala Lumpur, Malaya (*G. H. Corbett*), ex larva of a Pyralid, seem to belong to this species. The ocelli are also large, but are at about the same distance from the front ocellus as from the eye-margins, the antennae are slightly shorter and the scutellum is less distinctly striate.

3. *Euplectrus indicus*, sp. n.

♂♂. Black; clypeus and mandibles yellowish; abdomen with a rounded yellow spot on the second segment. Antennae yellow, last joints brownish. Legs yellow.

♀. Vertex and thorax with some scattered long whitish ciliae; ocelli small, the lateral ocelli closer to the front ocellus than to the eye-margins; eyes oval, not ciliate. Scape narrow, reaching to the level of the front ocellus; pedicel twice as long as broad; first funicle joint longer than the pedicel; the following joints subequal in length, all a little smaller than the first joint. Pronotum short, with a transverse carina. Mesonotum transversely striate and with a distinct median carina. Scutellum almost smooth, with thin longitudinal striae. Propodeum smooth, with the median carina strong and the spiracles distinctly oval. Wings with the marginal vein much longer than the submarginal; stigmal vein narrow. The longest tibial spur as long as the first two tarsal joints together. Abdomen very short triangular, truncate behind; petiole short, subquadrate, slightly rugulose.

♂. Similar; scape whitish, broadened in the middle, funicle joints narrower; abdomen small, triangular, narrower than the thorax; petiole a little longer than broad.

Length, ♀♂ 1.8-2.2 mm.

INDIA: United Provinces, Dehra Dun, 4 ♀ 3 ♂, 10.iv.1928, ex Geometrid larvae on mustard plant; 1 ♀, 17.iii.1928, ex cocoon on leaf of *Tectona grandis*; 1 ♀ 2 ♂, 17.iii.1928, ex *Apanteles obliqua* var. *niger*, Wilk. All received from Mr. J. C. M. Gardner, Forest Entomologist, Dehra Dun.

4. *Euplectrus parvulus*, sp. n.

♂♂. Black, clypeus and tegulae yellow; abdomen yellow with a transverse stripe before the end, lines on the sides of the second segment and the petiole brown. In the male almost the entire tip of the abdomen is brownish. Antennae yellow, slightly brownish at tip, scape white. Legs entirely whitish.

♀. Vertex almost smooth, ciliae very scattered; lateral ocelli at the same distance from the front ocellus as from the eye-margins; eyes oval. Antennae with the scape rather short, not reaching to the front ocellus; pedicel slightly longer than broad; funicle thicker, the four joints subequal in length, a little longer than the pedicel. Pronotum short, finely margined. Mesonotum rugulose-punctate, more strongly in the middle than on the parapsides, without median carina, but with deep parapsidal furrows. Scutellum finely shagreened, almost smooth. Propodeum smooth, with distinct median carina. Wings with marginal vein as long as the submarginal and only about twice as long as the stigmal vein. Tibial spur as long as first two tarsal joints together. Abdomen narrower and generally shorter than the thorax; petiole slightly broader than long or subquadrate, almost smooth above.

♂. Similar; antennal joints more elongate, scape slightly broadened in the middle.

Length, ♀♂ 1.1-1.6 mm.

INDIA: Punjab, Khanewal Pln., 10 ♀ 2 ♂, 28-30.vii.1928 (R.N.M.); Chichawatni, 2 ♀, 22.vi.1938; Daphar, 4 ♀ 3 ♂, 23.v.1938; United Provinces, Dehra Dun, 2 ♀, 27.iv.1938, 4 ♀ 5 ♂, vii.1938 (on slide); Allahabad, 1 ♂, 5.iv.1938, 3 ♀ 2 ♂, xi-xii.1938 (on slide), (S. N. Chatterjee). All ex larvae of *Plecoptera reflexa* on *Dahlbergia sissoo*. BURMA: Zigon, Thitcho Res., 2 ♀, 20.xii.1938, ex Pyralid defoliating *Stephene diversifolia*.

5. *Euplectrus coimbatorensis*, sp. n.

♀. Black; all the lower part of the head, below the insertion of the antennae, yellow; abdomen yellow above, slightly more orange-yellow at tip, only two lines

on the sides at base and the petiole black. Antennae orange-yellow, brownish towards tip, scape light yellow. Legs orange-yellow.

Head very transverse; eyes rounded; ocelli small, the lateral ocelli closer to the front ocellus than to the eye-margins. Scape narrow; pedicel about twice as long as broad; first funicle joint a little broader but not much longer than the pedicel, the following joints slightly shorter than the first. Pronotum very short. Mesonotum with irregular transverse striae. Scutellum finely reticulate. Propodeum smooth, with the median carina thin, higher in front. Wings with marginal vein a little longer than the submarginal and about three times as long as the stigmal vein. Hind tibial spur not quite as long as the first two tarsal joints together. Abdomen rounded, as broad as but shorter than the thorax; petiole subquadrate, finely shagreened almost smooth above.

Length, 1.6–1.7 mm.

SOUTH INDIA: Coimbatore, 3 ♀, 3.ix.1929 (B.R.P.), ex caterpillar on brinjal leaves (*Solanum melongena*).

6. *Euplectrus ceylonensis*, Howard 1896, Proc. U.S. Nat. Mus., **18**, p. 641.
Euplectrus insulanus, Crawford 1911, op. cit., **41**, p. 281 (*n. syn.*).

This species is easily recognised by its entirely black face, the light brown antennae with white scape and pedicel, the light yellow abdomen with tip, sides and petiole black, the reticulate mesonotum without median carina, the smooth scutellum and the rather long abdominal petiole, which is about twice as long as broad or little less. In the male the antennal scape is distinctly thickened towards the tip.

E. insulanus, Crawford, is certainly identical. Crawford said himself: "This species resembles *E. ceylonensis* Howard, which has the first joint of the tarsi much longer than the second." We have seen long series of specimens from Ceylon and Malaya and find that the relative length of the first and second tarsal joints is variable; it is often difficult in dry specimens to ascertain exactly the length of the first joint, which may be, in the same series, more or less longer than the second.

We have received and examined the following series:—

CEYLON: Peradeniya, 20 ♀ 3 ♂, 5.vi.1921, ex larva of *Lymantriid*; Heneratgoda, 10 ♀, 17.iv.1931, ex larva of *Nygmia flavo* on *Aleuritis fordii* (all from Dr. J. C. Hutson).

INDIA: Ayur, North Salem, 1 ♀, 15.xii.1930, host unknown; Singanallur, 3 ♀, 6.ii.1931 (T.V.S.), ex *Lymantriid*.

MALAYA: Kuala Lumpur, 2 ♀ 14 ♂, 25.xi.1922, ex *Nygmia scintillans*; Kuala Lumpur, 4 ♀, 27.vi.1924, ex *Nygmia scintillans*; Serdang, 10 ♀ 1 ♂, 21.xi.1924, ex *Lymantriid*; Klang, 5 ♀ 2 ♂, 22.vi.1925, ex *Lymantriid*; Setapak, 6 ♀ 8 ♂, 25.vii.1929, ex *Lymantriid* larva on *Vigna catjang*; Banting, 4 ♀ 4 ♂, 6.vi.1931, host unknown; Port Dickson, 2 ♀ 1 ♂, 28.iv.1932, ex larva on *Pterocarpus indicus*; Banting, 3 ♂, 30.v.1932, ex *Euproctis* sp.; Kuala Lumpur, 4 ♀, 12.xi.1936, ex Lepidopterous larva (All series bred and sent by G. H. Corbatt).

7. *Euplectrus petiolatus*, sp. n.

♂. Black; clypeus and a rounded spot on the abdomen yellow; antennae brown, scape and pedicel yellow; legs yellow.

♀. Head transverse, eyes short oval; ocelli rather large, the lateral ocelli at about the same distance from the front ocellus as from the eye-margins. Vertex smooth. Antennae with the scape narrow and elongate, but not reaching to the level of the front ocellus; pedicel narrow, about twice as long as broad; all funicle joints broader and longer than the pedicel, the first a little longer than the following joints. Pronotum short, narrowed in front, with a thin transverse carina. Mesonotum finely reticulate, without median carina. Scutellum smooth. Propodeum

smooth, the median carina narrow. Wings large, marginal vein a little longer than the submarginal vein and about four times as long as the stigmal vein. Hind legs strong, the coxae large, the longest hind tibial spur not quite as long as the first two tarsal joints together. Abdomen broadening behind, triangular, smaller than the thorax; petiole smooth, elongate, almost three times as long as broad.

♂. Similar, antennal scape slightly broadened; abdomen much smaller, about twice as long as the petiole.

Length, ♀ 1.7–2 mm.; ♂ 1.4 mm.

INDIA: United Provinces, Dehra Dun, 1 ♀, 12.xi.1925; 3 ♀ 1 ♂, 5.xi.1928 (S. N. Chatterjee), ex Lymantriid larva on teak.

African Species.

8. *Euplectrus fuscipes*, sp. n.

♂♂. Head and thorax entirely black; abdomen with a broad yellow spot near base; antennae brown, scape and pedicel light yellow; legs with all coxae brownish-black, the femora brownish, except at tip, the hind tibiae also more or less brown in the middle.

♀. Head very transverse, almost smooth, with scattered ciliae on vertex; ocelli small, the lateral ocelli a little closer to the front ocellus than to the eye-margins; eyes rounded. Antennae inserted near the clypeus; scape narrow, not reaching quite to the front ocellus; pedicel narrow, about twice as long as broad; funicle joints a little broader but not longer than the pedicel, all subequal in length. Pronotum very short, the transverse carina very thin and not far from the hind margin. Mesonotum reticulate, without median carina. Scutellum finely shagreened; axillae smooth. Propodeum smooth, median carina strong. Marginal vein as long as the submarginal vein and about three times as long as the thin stigmal vein. The longest hind tibial spur not quite as long as the first two tarsal joints together. Abdomen rounded, about as long as the thorax, but shorter; petiole shagreened, short, broader than long.

♂. Similar, smaller; scape distinctly broadened in the middle; abdomen small and triangular, petiole punctate, about as long as broad.

Length, ♀ 1.7–1.8 mm.; ♂ 1.5 mm.

UGANDA: Kampala, 5 ♀ 2 ♂, 3.ix.1917 (C. C. Gowdey), host unknown, 6; 1 ♂, 20.v.1925 (G. L. R. Hancock), ex Lepidopterous larva, 2 ♀, 3.vii.1926 (G. L. R. H.), ex young caterpillar.

9. *Euplectrus nigrescens*, sp. n.

♀. Head and thorax entirely black, except tegulae; abdomen with a broad yellow spot above and almost entirely yellow below; antennae brownish yellow; legs entirely yellow.

Head transverse; ocelli small, the lateral ocelli at about the same distance from the front ocellus as from the eye-margins; vertex and face almost smooth. Antennae inserted near the clypeus; scape elongate, reaching to the level of the front ocellus; pedicel short, not much longer than broad; first funicle joint narrow and longer than the pedicel, the following joints gradually shorter, but all distinctly longer than broad. Pronotum short, transverse carina inconspicuous. Mesonotum irregularly transversely striate, with a distinct median carina. Scutellum shagreened, axillae smooth. Propodeum smooth, with the median carina strong. Wings large; marginal vein a little longer than the submarginal vein, the costal cell distinctly broadened; stigmal vein rather long, more than one-third the length of the marginal vein. The longest hind tibial spur not quite as long as the first two tarsal joints together;

fourth joint of tarsus large, as long as or longer than the first. Abdomen rounded, almost as broad as the thorax, but shorter; petiole subquadrate, shagreened.

Length, 2-2.3 mm.

SOUTH AFRICA: Cape Prov., Mossel Bay, 1 ♀, xii.1921; Witzenberg Valley, 3,000 feet, 1 ♀, i.1921; Milnerton, 2 ♀, i-ii.1926 (*R. E. Turner*); host unknown.

10. *Euplectrus cinctiventris*, sp. n.

♂♂. Black; clypeus orange-yellow, mandibles light yellow; abdomen yellow with a transverse band before the end, the sides narrowly and the petiole, black; in the male the band is broader and the tip scarcely yellow. Antennae yellow, the last two funicle joints and the club more or less brownish. Legs entirely yellow.

♀. Head with scattered white ciliae on the vertex; lateral ocelli slightly closer to the front ocellus than to the eye-margin. Antennae with the scape narrow, not reaching quite to the front ocellus; pedicel narrow, about twice as long as broad; first funicle joint about one and a half times longer than the pedicel, but not much longer than the second joint, the two following joints a little shorter and broader. Pronotum short, with a transverse carina near the hind margin. Mesonotum finely shagreened and striate, with a distinct median carina. Scutellum shagreened, almost smooth on the sides and at tip. Propodeum smooth, the median carina distinct. Wings with the marginal vein a little longer than the submarginal vein; the costal cell broadened; stigmal about as long as the third of the marginal vein. The longest hind tibial spur almost as long as the first two tarsal joints together. Abdomen short, rounded or triangular; petiole subquadrate, rugulose.

♂. Similar; scape somewhat broadened and curved towards tip, the funicle joints narrower and a little longer; abdomen smaller, triangular.

Length, ♀ 1.8-2 mm.; ♂ 1.6-1.7 mm.

UGANDA: Kampala, 51 ♀ 2 ♂, 14.i.1930 (*H. Hargreaves*), ex caterpillar on grass.
SOUTH AFRICA: Cape Prov., Ceres, 1 ♀, ii.1921; George, 1 ♀, xi.1921; Mossel Bay, 1 ♀, xii.1921 (*R. E. Turner*).

11. *Euplectrus ceresensis*, sp. n.

♀. Black; clypeus reddish; abdomen yellow, only the sides and the petiole black; antennae yellow, more or less brownish towards tip; legs entirely yellow.

Head almost smooth, eyes oval; ocelli small, the lateral ocelli closer to the front ocellus than to the eye-margins. Antennae inserted above the clypeus; scape elongate, reaching almost to the front ocellus; pedicel narrow, about twice as long as broad; funicle joints subequal in length, each a little longer than the pedicel. Pronotum short. Mesonotum finely transversely striate, with a median carina which is sometimes more or less shortened in front or almost lacking. Scutellum shagreened. Propodeum smooth, median carina narrow. Wings large, marginal vein longer than the submarginal vein, the costal cell distinctly broadened. The longest tibial spur as long as the first two tarsal joints together. Abdomen rounded, almost as broad as the thorax but much shorter; petiole finely punctate, subquadrate.

Length, 1.5-2 mm.

SOUTH AFRICA: Cape Prov., Ceres, 7 ♀, i-iii.1921; Milnerton, 2 ♀, i.1926 (*R. E. Turner*), host unknown.

12. *Euplectrus turneri*, sp. n.

♀. Head and thorax entirely black, except tegulae; abdomen with a broad yellow spot near base, above and below; antennae brown, scape whitish; legs yellow.

Head transverse, eyes rounded; lateral ocelli at about the same distance from the front ocellus as from the eye-margins. Antennal scape narrow, reaching almost

to the front ocellus ; pedicel narrow, about twice as long as broad ; funicle broadening strongly from the first to the fourth joint, the first scarcely broader and a little longer than the pedicel, the fourth about twice as broad as the first and subquadrate. Pronotum short, narrowed in front. Mesonotum rugulose in the middle, finely shagreened on the sides, without median carina. Scutellum shagreened, with irregular small longitudinal striation. Axillae and propodeum smooth ; the median carina on propodeum thin. Wings with the marginal vein about as long as the submarginal vein and three times as long as the stigmal vein. The longest hind tibial spur as long as first two tarsal joints together. Abdomen short, more or less rounded or subtriangular, as broad as the thorax but shorter ; petiole small, about as long as broad.

Length, 1.7–2 mm.

SOUTH AFRICA, Cape Prov., Mossel Bay, 3 ♀, iv–vi.1921, 6 ♀, vii–viii.1921, 5 ♀, xii.1921, 3 ♀, i–ii.1922 (*R. E. Turner*), host unknown.

13. *Euplectrus nigroclpeatus*, sp. n.

♀. Head and thorax entirely black ; abdomen with a broad yellow spot near base ; antennae light brown, scape and pedicel yellow ; legs yellow.

Vertex and face smooth ; lateral ocelli slightly closer to the front ocellus than to the eye-margins ; eyes rounded. Antennae with the scape narrow, reaching almost to the front ocellus ; pedicel narrow, more than twice as long as broad ; first funicle joint broader but not longer than the petiole ; the following joints all elongate and subequal in length with the first. Pronotum short, narrowed in front, without carina. Mesonotum finely reticulate in the middle, more finely shagreened on the sides, without median carina. Scutellum very finely shagreened, almost smooth. Propodeum smooth, median carina very thin. Wings large ; marginal vein longer than the submarginal vein, the costal cell slightly broadened ; stigmal vein narrow ; postmarginal vein about one and a half times longer than the stigmal. The longest hind tibial spur only slightly longer than the metatarsus. Abdomen rounded, much shorter than the thorax ; petiole shagreened, a little longer than broad.

Length, 1.7–1.9 mm.

SOUTH AFRICA : Cape Prov., Mossel Bay, 3 ♀, iv–xii.1921 ; Zululand, Eshowe, 1 ♀, vi.1926 ; Natal, Kloof, 1,500 feet, 1 ♀, viii.1926 (*R. E. Turner*) ; host unknown.

14. *Euplectrus rufiventris*, sp. n.

♀. Black ; clypeus reddish yellow ; abdomen entirely reddish yellow, only lines on the sides at base and petiole black ; antennae yellow, becoming gradually brownish at tip ; legs yellow.

Vertex and face smooth ; eyes rounded ; ocelli small, lateral ocelli closer to the front ocellus than to the eye-margins. Antennae inserted above the clypeus ; scape elongate, reaching to the level of the front ocellus ; pedicel narrow, about twice as long as broad ; first funicle joint scarcely longer than the pedicel, the following joints shorter, a little longer than broad. Pronotum very short, not marginate. Mesonotum finely reticulate in the middle, shagreened on the sides. Scutellum finely shagreened ; axillae smooth. Propodeum smooth, with a thin median carina. Wings large, marginal vein a little longer than the submarginal vein and not quite three times as long as the stigmal vein. The longest hind tibial spur a little longer than the metatarsus. Abdomen rounded, as broad as the thorax but shorter ; petiole shagreened, subquadrate or slightly longer than broad.

Length, 1.4–1.8 mm.

SOUTH AFRICA : Cape Prov., Mossel Bay, 1 ♀, vii.1921 ; Pondoland, Port St. John, 1 ♀, iii.1923 ; Zululand, Gingindlovu, 1 ♀, vii.1926 (*R. E. Turner*), host unknown.

15. *Euplectrus epiplemae*, sp. n.

♀♂. Black ; clypeus orange-yellow ; abdomen with a broad yellow spot near base ; antennae light brown, scape whitish ; legs yellow.

♀. Head transverse ; eyes rounded ; ocelli small, the lateral ocelli closer to the front ocellus than to the eye-margins ; cheeks a little shorter than the diameter of an eye. Antennae with the scape narrow, not reaching to the front ocellus ; pedicel narrow, about twice as long as broad ; first funicle joint slightly longer than the pedicel, the following joints shorter, but all longer than broad. Pronotum short, narrowed in front, with a thin transverse carina before the hind margin. Mesonotum strongly reticulate in the middle, without median carina, the sides more finely shagreened. Scutellum very finely reticulate ; axillae smooth. Propodeum smooth, with the median carina distinct. Wings large ; marginal vein longer than the submarginal vein and about three times as long as the stigmal vein. Hind femora slightly thickened ; the longest hind tibial spur a little shorter than the first two tarsal joints together. Abdomen short, truncate behind, a little narrower and much shorter than the thorax ; petiole slightly longer than broad, rugulose above.

♂. Similar ; scape slightly thickened, first funicle joint narrower and not longer than the second. Abdomen small, triangular.

Length, ♀ 1.5–1.8 mm. ; ♂ 1.3–1.5 mm.

UGANDA : Kampala, 10 ♀ 3 ♂, 21.xii.1933 (*H. Hargreaves*), ex caterpillar on coffee. BELGIAN CONGO : Kivu, Mulungu, 2 ♀, 1937 (*P. Lefèvre*), ex *Epiplema dohertyi* on coffee. SOUTH AFRICA : Cape Prov., Ceres, 3 ♀ 1 ♂, xi.1920–iii.1921 ; Mossel Bay, 1 ♀, vi.1921 ; Somerset East, 1 ♀, xii.1930 ; Pondoland, Port St. John, 3 ♀, iii–v.1923 ; Zululand, Gingindlovu, 1 ♀, vi.1926 (*R. E. Turner*) ; host unknown.

16. *Euplectrus singularis*, sp. n.

♀♂. Black ; clypeus yellow ; abdomen with a broad yellow spot on the second segment ; antennae light brown, scape whitish ; legs yellow.

♀. Head transverse ; ocelli small, the lateral ocelli closer to the front ocellus than to the eye-margins. Pronotum narrowed in front, short. Mesonotum finely reticulate, with a short median carina, more or less distinct, behind. Scutellum more finely reticulate. Propodeum smooth, with a distinct median carina. Wings large, marginal vein a little longer than the submarginal vein, about three times as long as the stigmal and twice as long as the postmarginal vein. The longest hind tibial spur not quite as long as first two tarsal joints together. Abdomen small, truncate behind, not much narrower but much shorter than the thorax ; petiole slightly longer than broad, punctate above.

♂. Similar ; the antennal scape especially thick, inflated in front ; funicle joints narrower than in the female. Abdomen almost as broad as but shorter than the thorax.

Length, ♀♂ 1–1.6 mm.

UGANDA : Kampala, 3 ♀ 1 ♂, 22.xii.1923 (*H. Hargreaves*), ex small caterpillar on coffee ; Kampala, 2 ♀ 1 ♂, 1927 (*G. L. R. Hancock*), ex reticulated cocoon (under young caterpillar) ; Kampala, 2 ♀ 2 ♂, iii.1927 (*G.L.R.H.*), ex cocoon of *Apanteles*.

This species could belong to the genus *Pachyscapa*, Howard, which is a synonym of *Euplectrus*, Swed.

17. *Euplectrus aburiensis*, sp. n.

♀♂. Black ; head of female with face below the antennae and cheeks yellow ; head of male entirely yellow ; abdomen yellowish, only the sides near base and the petiole black ; antennae brown, scape yellow ; legs yellow.

♀. Vertex and face smooth; ocelli small, the lateral ocelli closer to the front ocellus than to the eye-margins; eyes rounded; cheeks a little longer than the diameter of an eye. Antennae with the scape narrow, not reaching to the front ocellus; pedicel narrow, not quite twice as long as broad; funicle joints all slightly longer than the pedicel and all about twice as long as broad. Pronotum short, narrowed in front. Mesonotum finely reticulate in the middle, without median carina, almost smooth on the sides. Axillae, scutellum and propodeum almost quite smooth; median carina of propodeum distinct but thin. Wings with marginal vein not longer than the submarginal vein and only about twice as long as the stigmal vein. The longest hind tibial spur almost as long as the first two tarsal joints together. Abdomen short oval, as broad and as long as the thorax or slightly broader; petiole small, broader than long or subquadrate.

♂. Quite similar; abdomen rounded, as broad as the thorax but shorter.

Length, ♀♂ 1.3-1.7 mm.

GOLD COAST: Aburi, 4 ♀ 1 ♂, i.1939 (G. S. Cotterell), ex Geometrid larva.

18. *Euplectrus hargreavesi*, sp. n.

♀. Black; face below the antennae and cheeks yellow, except a narrow margin near the eyes, abdomen yellow with a transverse band before the end and the sides black; antennae yellow, gradually brownish towards the tip; legs yellow.

Head transverse; ocelli small, the lateral ocelli closer to the front ocellus than to the eye-margins; eyes rounded; cheeks a little longer than the diameter of an eye. Antennae inserted near the clypeus; scape narrow, reaching scarcely to the front ocellus; pedicel narrow, more than twice as long as broad; first funicle joint not much longer than the pedicel, the following joints slightly shorter than the first. Pronotum short. Mesonotum rugulose-reticulate in the middle, without median carina, shagreened on the sides. Scutellum finely shagreened, almost smooth. Propodeum smooth, the median carina thin. Wings large; marginal vein about as long as the submarginal vein and less than three times as long as the stigmal vein. The longest hind tibial spur shorter than the first two tarsal joints together. Abdomen rounded, narrower and much shorter than the thorax; petiole narrow, scarcely longer than broad, almost smooth above.

Length, 1.7 mm.

UGANDA: Kampala, 5 ♀, 27.viii.1929 (H. Hargreaves), ex caterpillar on sweet potato.

19. *Euplectrus brevitarsis*, sp. n.

♀♂. Black; head of female with the face below the antennae yellow, the cheeks half yellow, half black; head of male quite yellow; abdomen yellow, with the hind third, the sides and the petiole black; antennae yellow, brownish near tip; legs yellow.

♀. Head very transverse; ocelli small, the lateral ocelli closer to the front ocellus than to the eye-margins; eyes rounded. Antennae inserted near the clypeus; scape slightly broadened in the middle, reaching scarcely to the front ocellus; pedicel narrow, almost three times as long as broad; first funicle joint about as long as the pedicel, the following joints a little shorter. Pronotum short. Mesonotum strongly reticulate in the middle, without median carina, shagreened on the sides. Scutellum shagreened or slightly longitudinally striate. Propodeum smooth. Wings large; marginal vein a little longer than the submarginal vein and about three times as long as the stigmal vein. Hind legs strong, femora and tibiae somewhat thickened; hind tarsi thick and short, the metatarsus only about twice as long as broad, the 2nd and 3rd joint scarcely longer than broad, the 4th very large, almost as long as

the three preceding joints together; the longest hind tibial spur relatively short; the middle tarsi are also short, but narrower. Abdomen rounded, almost as broad as the thorax but much shorter; petiole slightly broader than long, shagreened above.

♂. Similar, smaller; antennal scape broader than in the female; hind tarsi narrow, joints 2 and 3 as long as the first, 4 as long as two preceding joints together; abdomen short, triangular.

Length, ♀ 1.5–2 mm.; ♂ 1.3 mm.

UGANDA: Kampala, 12 ♀ 2 ♂, 20.viii.1930 (*H. Hargreaves*), ex undetermined black caterpillar.

20. *Euplectrus laphygmae*, sp. n.

♀♂. Black; head of female with face below the antennae and cheeks (except near eyes) yellow; head of male entirely yellow; abdomen yellow with hind half, the sides and the petiole black; antennae yellow, more brownish towards tip; legs yellow.

♀. Head transverse; lateral ocelli closer to the front ocellus than to the eye-margins; eyes short oval; cheeks as long as the diameter of an eye. Antennae with the scape narrow, reaching almost to the front ocellus; pedicel about twice as long as broad; the four funicle joints subequal in length, the first slightly longer, the fourth as long as the pedicel. Pronotum short, with a faint transverse carina near the hind margin. Mesonotum roughly reticulate in the middle, more finely on the sides, without median carina. Scutellum very finely shagreened. Propodeum smooth with the median carina distinct. Wings large; marginal vein as long as the submarginal vein and about three times as long as the stigmal vein. The longest hind tibial spur as long as the first plus half the second joints; tarsal joints narrow, all longer than broad. Abdomen short oval, about as long and as broad as the thorax; petiole subquadrate, almost smooth above.

♂. Similar; scape distinctly flattened and broadened near tip; abdomen triangular, almost as broad as the thorax but shorter.

Length, ♀♂ 1.2–2 mm.

NYASALAND: Zomba, 18 ♀ 6 ♂, iv.1936 (*C. Smee*), ex *Laphygma exempta*; Ntonowe, 3 ♀ 1 ♂, 24.i.1923 (*C. Smee*), external parasite of *L. exigua* on tobacco. UGANDA: Kampala, 3 ♀ 2 ♂, 8.iv.1929 (*H. Hargreaves*), ex Noctuid caterpillar. S. RHODESIA: Salisbury, 3 ♀ 1 ♂, ii.1930, ex *Laphygma exempta*. SOUTH AFRICA: Transvaal, Springbok Flats, 9 ♀, 6.ii.1929 (*G. C. Haines*), ex larva of *Laphygma exempta*; Barberton, 6 ♀, 6.iii.1931 (*G. C. Ulyett*), ex larva of *Plusia orichalcea* on soya beans; Durban, 5 ♀, 20.ii.1919, ex *Laphygma exempta*; Potch, 3 ♀, 31.iii.1936 (*M. S. Oosthuizen*), ex larva of *L. exempta*; Cape Province, Mossel Bay, 8 ♀ 1 ♂, iv.1921–i.1922; Pondoland, Port St. John, 1 ♀, iii.1923; Transkei, Umtata, 2 ♀, ii iii.1923; Zululand, Eshowe, 1 ♀, v.1926; Zululand, Gingindhlovu, 1 ♂, vii.1926 (*R. E. Turner*). ANGLO-EGYPTIAN SUDAN: Homel el Nil, 3 ♀, 4.x.1933 (*H. Wood*), ectoparasite of larva of *Heliothis* sp. SENEGAL: Bambey, 1 ♀, ii.1939 (*J. Risbec*), ex Geometrid on cabbage.

21. *Euplectrus seychellensis*, sp. n.

♀♂. Black; head of female with only the clypeus below the antennae and the mouth yellow, cheeks almost entirely black; head of male entirely yellow; abdomen with broad yellow spot near base; antennae brownish, scape yellow; legs yellow.

♀. Vertex and face smooth; eyes rounded, cheeks shorter than the diameter of an eye; lateral ocelli at about the same distance from the front ocellus as from the eye-margins. Antennae with the scape narrow, reaching almost to the front ocellus; pedicel narrow, about twice as long as broad; first funicle joint longer than the

pedicel, the following joints a little shorter than the first, but all slightly longer than the pedicel. Pronotum short, transverse carina not or only faintly indicated. Mesonotum very finely shagreened, almost smooth. Axillae, scutellum and propodeum smooth; median carina of propodeum distinct. Wings with marginal vein as long as the submarginal vein and about three times as long as the stigmal vein. The longest hind tibial spur about as long as the metatarsus; tarsal joints narrow and elongate. Abdomen short oval or triangular, smaller than the thorax; petiole punctate, dull, subquadrate.

♂. Similar, smaller; scape flattened and broadened towards tip; abdomen very small, triangular, much shorter than the thorax.

Length, ♀ 1.7–2.2 mm.; ♂ 1.2 mm.

SEYCHELLES Is.: Silhouette, 4 ♀ 1 ♂, 1908, host unknown.

This species was named "*Euplectrus bicolor* Swed." by Masi, but differs distinctly from the European species, which we redescribe below. *E. seychellensis* may be only a variety of *E. laphygmae*.

Palearctic Species.

22. *Euplectrus bicolor*, Swederus 1795, Svensk. Vet. Akad. Handl., 16, p. 204.

♀♂. Black; clypeus orange-yellow; abdomen with a more or less broad reddish-yellow spot near base; antennae yellow, turning to brownish towards tip; legs entirely yellow.

♀. Head transverse, fronto-vertex almost smooth; ocelli small, the lateral ocelli slightly closer to the front ocellus than to the eye-margins; eyes short oval; cheeks about as long as the diameter of an eye. Antennae inserted near the clypeus; scape elongate, reaching almost to the level of the front ocellus; pedicel narrow, about twice as long as broad; first funicle joint longer than the pedicel, the following joints shorter than the first, but all a little longer than the pedicel; club about as long as the first funicle joint. Pronotum short, narrowed in front, with a thin transverse carina not far from the hind margin. Mesonotum strongly reticulate in the middle, more finely shagreened on the sides, without median carina, or with a more or less shortened carina behind. Scutellum with fine and irregular longitudinal striation, sometimes mixed with a fine reticulation. Propodeum smooth, the median carina distinct. Wings large, submarginal vein shorter than the marginal, the costal cell a little broadened; marginal vein about three times as long as the stigmal vein and twice as long as the postmarginal vein. Hind legs strong, the longest tibial spur almost as long as the first two tarsal joints together. Abdomen more or less rounded, as broad as the thorax but shorter; petiole subquadrate, rugulose above.

♂. Similar; scape slightly broadened in front; funicle joints more elongate; abdomen small, triangular, shorter and narrower than the thorax.

Length, ♀ 2–2.5 mm.; ♂ 1.2–2 mm.

Redescribed from the following material:—

ENGLAND: Old specimens in the British Museum: 4 ♀ (Walker's coll.); 2 ♀ (Stephens' coll.); 1 ♀ (B. Cooke's coll.). New series: Cheshire, Delamere Forest, 15 ♀ 8 ♂, 1907 (*Hugh Main*), ex larva of *Aplecta nebulosa*; Berks, Reading, 20 . 21 ♂, v–vi.1936 (*H. L. Dolton*), ex *Miselia tincta*. SWEDEN: Skane, 10 ♀ 27 ♂, vii.1938 (*D.M.S. & J. F. Perkins*), hosts unknown; 9 ♀ 6 ♂, vi.1938 (*J. F. Perkins*), from cocoons under dead caterpillar; 6 ♂, 29.vii.1931 (*F. Nordstrom*), ex *Crino setara*. FRANCE: Ain, Meyton, 2 ♂, 18.vi.1913 (*J. Riel*), ex caterpillar on *Artemisia vulgaris*; Le Puy, 1 ♀, 2.v.1933 (*H. Maneval*), host unknown; Corsica, 1 ♀ (coll. Marshall in British Museum, under the name *Euplectrus intactus*, Walker).

23. *Euplectrus nigriceps*, sp. n.

♂. Head and thorax entirely black, except tegulae; abdomen mostly yellow, the end and sides brownish, the base and petiole black; antennae light brown, scape yellow; legs yellow.

♀. Head transverse, smooth; ocelli small, the lateral at about the same distance from the front ocellus as from the eye-margins; eyes rounded, cheeks as long as the diameter of an eye, strongly converging towards mouth. Antennae with the scape elongate, reaching to the level of the front ocellus; pedicel narrow, not much longer than broad; the four funicle joints subequal in length, all longer than the pedicel, but not quite twice as long as broad. Pronotum short, transverse carina not distinct. Mesonotum finely transversely striate, the median carina distinct and complete. Axillae and scutellum almost smooth. Propodeum smooth, the median carina thin. Wings large, marginal vein about as long as the submarginal vein and not quite three times as long as the stigmal vein. The longest hind tibial spur as long as the first plus half the second joint of tarsus together. Abdomen short oval, as broad as the thorax but shorter; petiole finely rugulose, subquadrate or slightly broader than long.

♂. Similar, scape only slightly broadened, funicle joints more elongate; abdomen triangular, narrower and shorter than the thorax.

Length, ♀♂ 1.8–2 mm.

Described from 2 ♀ and 1 ♂ from Walker's collection in the British Museum. They stood mixed with specimens of *Euplectrus bicolor*, Swed., from Britain, but have no locality labels. In our opinion they differ distinctly from *E. bicolor* by their entirely black head, yellowish abdomen and the different structure of the thorax.

24. *Euplectrus cacoeeciae*, sp. n.

♀. Black; clypeus, tegulae and a broad spot near base of abdomen yellow; antennae yellow, brownish at tip, scape whitish; legs yellow.

Head very transverse; lateral ocelli at the same distance from the front ocellus as from the eye-margins; eyes short oval. Antennae with scape elongate, but not reaching to the front ocellus; pedicel narrow, not quite twice as long as broad; first funicle joint much longer than the pedicel, the following joints shorter, but all longer and broader than the pedicel. Pronotum short, narrowed in front, the transverse carina not distinct. Mesonotum finely transversely striate, with a distinct and complete median carina. Scutellum finely longitudinally striate. Propodeum smooth, the median carina strong. Wings large, costal cell distinctly broadened; marginal vein a little longer than the submarginal vein and about three times as long as the stigmal vein. Hind legs strong; hind tibial spur almost as long as the first two tarsal joints together. Abdomen rounded or subtriangular, as broad as the thorax but shorter; petiole finely punctate, subquadrate or slightly longer than broad.

Length, 2 mm.

BULGARIA: Sofia, 2 ♀, 1932 (*Dr. P. Tchorbadjiev*), ex larva of *Cacoeecia rosana*.

This species is perhaps only a variety of *bicolor*, but the sculpture of the mesonotum differs distinctly from the North European series.

25. *Euplectrus phthorimaeae*, sp. n.

♀♂. Black; clypeus and mouth yellow, cheeks mostly black; abdomen almost entirely yellow, with a broad transverse band before the end, the sides and the petiole, black; antennae yellow, light brown at tip, scape lighter; legs yellow.

♀. Head transverse; lateral ocelli at about the same distance from the front ocellus as from the eye-margins; eyes short oval. Antennae with the scape elongate,

reaching almost to the level of the front ocellus ; pedicel narrow, almost twice as long as broad ; all funicle joints longer than the pedicel, the first longer than the three others. Pronotum short, transverse carina very thin. Mesonotum finely transversely striate, with a more or less complete median carina. Scutellum finely reticulate. Propodeum smooth, with the median carina distinct. Wings large, marginal vein longer than the submarginal vein and about three times as long as the stigmal vein. The longest hind tibial spur almost as long as the first two tarsal joints together. Abdomen rounded or triangular, as broad as the thorax but shorter ; petiole small, broader than long, almost smooth above.

♂. Similar ; antennal scape broadened and flattened in front ; funicle joints narrow and more elongate ; abdomen triangular, as broad and almost as long as the thorax.

Length, ♀♂ 2-2.2 mm.

CYPRUS : Nicosia, 1 ♀ 1 ♂, 13.xi.1933 (*Th. Shiakides*), ex *Phthorimaca operculella*.

PALESTINE : Tel Aviv, 2 ♀, 15.vii.1927 (*F. Bodenheimer*), host unknown.

26. *Euplectrus liparidis*, sp. n.

♀. Black ; face below the antennae and cheeks almost entirely yellow ; abdomen mostly yellow, with a more or less broad transverse band above before the end, the sides and the petiole, black ; antennae yellow, brown at tip ; legs yellow.

Head transverse ; lateral ocelli slightly closer to the front ocellus than to the eye-margins ; eyes short oval. Antennae with the scape elongate, but not quite reaching to the front ocellus ; pedicel narrow, about twice as long as broad ; funicle joints longer than the pedicel, the first more than the fourth. Pronotum short, with a thin transverse carina. Mesonotum strongly reticulate, without median carina. Scutellum distinctly longitudinally striate. Propodeum smooth, with the median carina strong. Wings large, marginal vein as long as the submarginal vein and not quite three times as long as the stigmal vein. The longest hind tibial spur as long as the first two tarsal joints together. Abdomen short, rounded, as broad as the thorax but much shorter ; petiole a little longer than broad, rugulose and with a longitudinal carina above.

Length, 2 mm.

ALGERIA : Algiers, Bou Zegza Mts., 4 ♀, ix.1936 (*M. Delassus*), ex *Lymantria dispar*.

APPENDIX.

Euplectrus species from Asia which have not been included in this revision.

ASHMEAD, W. H., J.N.Y. Ent. Soc., **12**, 1904, p. 16.

Euplectrus manilae, Ashm.

♀. Length 1.5 mm. Head and thorax black, shining, with some long, sparse hairs, the mesonotum posteriorly delicately shagreened, but without a median carina posteriorly ; mouth-parts, scape, pedicel, legs including coxae, and the abdomen beneath and a large spot on disk above, yellowish-white, rest of antennae light brown, the club darker, the petiole of the abdomen and the body of abdomen at the sides and apex black. Wings hyaline, the veins pale or yellowish.

PHILIPPINES : Manila, ex *Papilio alphenor*, Cram.

Euplectrus philippinensis, Ashm.

♀. Length 1.5 mm. Brownish-yellow, with sparse long hairs, the eyes, the flagellum and two or three streaks on dorsum of abdomen brown or brown-black; legs yellowish or waxy-white; wings hyaline, the veins pale yellowish. The brown-black flagellum is pubescent, slightly thickened towards apex, joints 1 and 2 about twice as long as thick, the following a little shorter but thicker. The head is polished, impunctate, while the thorax, except at sides and the metathorax which are smooth, is delicately shagreened.

PHILIPPINES: Manila, from a slug caterpillar.

ASHMEAD, W. H., J.N.Y. Ent. Soc., **12**, 1904, p. 163.

Euplectrus japonicus, Ashm.

♂. Length 1.5 mm. Black and shining, the abdomen with a yellow spot at base above, brownish-yellow beneath; antennae and legs pale yellowish, the front and middle coxae yellowish-white, the hind coxae black; wings hyaline, the veins pale. The head is highly polished, impunctate, clothed with some sparse long hairs; the pedicel is obconical, a little longer than thick at apex; first funicle joint stouter, about one and a half times as long as thick, the second hardly longer than thick, the third and fourth stouter, a little wider than long; club short, ovate, stouter; the mesonotum is finely rugulose but without a median carina posteriorly, the scutellum including the axillae and the metathorax are perfectly smooth, highly polished, the latter with a sharp median carina.

JAPAN: from an unknown Noctuid larva.

Euplectrus nigromaculatus, Ashm.

♀. Length 1.6 mm. Brownish-yellow, the eyes brown, a transverse band on occiput, one on the front of the pronotum and one on the front of the mesonotum, a spot on the lateral mesothoracic lobe, the metathorax and spots on the lateral margins of the abdomen, black; scape and legs yellowish-white; flagellum brownish; wings hyaline, the marginal and postmarginal veins brown, the submarginal and the stigmal veins yellowish.

JAPAN: Hakone. Many specimens.

CRAWFORD, J. C., Proc. U.S. Nat. Mus., **39**, 1911, p. 620.

Euplectrus fukaii, Crawl.

♀. Length about 2 mm. Head and thorax black, clypeal area whitish; antennae testaceous, becoming brown apically; pedicel about one-half as long as first joint of funicle, following joints of funicle successively shorter, the last longer than wide; median lobe of mesonotum coarsely rugoso-reticulate, the lateral lobes more finely and indistinctly so; scutellum and axillae finely, indistinctly reticulated with impressed lines; legs entirely reddish-testaceous, longer spur of hind tibiae as long as first two joints of hind tarsi; first joint of hind tarsi not much longer than the second; abdomen with a large basal testaceous spot.

♂. Unknown.

JAPAN: Atami, 7 specimens (*A. Koebele*); Konosu, Saitama, 1 specimen (*T. Fukai*), ex *Naranga diffusa*.

Euplectrus koebelei, Crawl.

♀. Length 2 mm. Head and thorax, including clypeal region, black; scape and pedicel yellowish, funicle brownish, becoming darker apically; first joint of

funicle not distinctly longer than pedicel, following joints shorter, hardly longer than wide; median lobe of mesonotum coarsely rugosely reticulated, posteriorly with a short median carina, lateral lobes with much finer sculpture; reticulations of axillae and scutellum of impressed lines and still more indistinct; propodeum with a median and lateral carinae, between these smooth; pleurae smooth, legs, including coxae, reddish testaceous; first joint of hind tarsi almost twice as long as second; longer spur of hind tibiae as long as joints one and two of hind tarsi together; abdomen brownish, with a large basal testaceous spot, venter largely pale.

♂. Unknown.

JAPAN: Hakone, 6 specimens (*A. Koebele*).

Euplectrus kuwanae, Crawford.

♀. Length about 2 mm. Head and thorax black; clypeal area white; scape and pedicel light yellow, funicle more brownish; pedicel distinctly shorter than first joint of funicle, following joints of funicle successively shorter, but even the last longer than broad; median lobe of mesonotum coarsely rugosely reticulated, the lateral lobes with somewhat finer reticulations; axillae very indistinctly reticulated with impressed lines; scutellum with irregularly longitudinal lines, basally these more or less reticulated; legs entirely yellowish; longer spur on hind tibiae as long as first two joints of tarsi; first joint of hind tarsi almost twice as long as second; abdomen dark brown, with a large basal light spot; venter largely pale.

♂. Length about 1.5 mm. Similar to the female, except in secondary sexual characters; the first joint of funicle about twice as long as the pedicel.

JAPAN: 1 ♀ 1 ♂ (*Prof. S. I. Kuwana*), ex *Parnara guttatus*; Atami, 3 specimens (*A. Koebele*).

Crawford gives also the following key to the species from Japan:—

1. Head and thorax partly yellow.....*nigromaculatus*, Ashm.
Head and thorax black.....2
 2. All coxae pale.....3
Hind coxae black.....*japonicus*, Ashm.
 3. Scutellum finely indistinctly reticulated.....4
Scutellum at base deeply reticulated, apically longitudinally rugose
kuwanae, Crawford.
 4. Clypeal area black*koebelei*, Crawford.
Clypeal area white.....*fukuii*, Crawford.
- (Correction in key made according with note by Crawford in the next paper).

CRAWFORD, J. C., Proc. U.S. Nat. Mus., **41**, 1911, p. 280.

Euplectrus medianensis, Crawford.

♀. Length about 1.5 mm. Black, the clypeal area whitish, abdomen brown, with a large basal testaceous spot, venter largely testaceous; antennae brown, the scape and pedicel testaceous; first joint of funicle slightly longer than the pedicel; following joints slightly longer than wide, subequal, about as long as the pedicel; face indistinctly lineolated; mesoscutum finely rugose, axillae and scutellum finely reticulated with impressed lines; propodeum with the usual median carina and anterior median lip; legs including coxae testaceous; longer spur of hind tibiae reaching slightly beyond apex of second tarsal joint; first joint of hind tarsi almost twice as long as second.

♂. Length about 1.25 mm. Similar to the female; the antennae entirely yellowish, the scape somewhat dilated in front; legs yellowish.

SUMATRA: Medan, Deli. Many specimens reared by Dr. de Bussy from an unknown Lepidopterous host.

CRAWFORD, J. C., Proc. U.S. Nat. Mus., **42**, 1912, p. 9.

Euplectrus nyctemerae, Crawl.

♀. Length 1.75 mm. Black, the scape, pedicel and legs, including coxae, testaceous; rest of antennae light brown; pedicel about as long as joint one of funicle, the latter not distinctly longer than the second joint; third and fourth joints about as long as second; middle lobe of mesoscutum reticulately rugose, at rear medially with one or two longitudinal rugose [*sic*] which extend forward about one-third the length of the mesoscutum; lateral lobes finely rugulose; scutellum basally indistinctly reticulate; first joint of hind tarsi almost twice as long as second, longer spur on hind tibiae not reaching apex of second tarsal joint; abdomen with a large testaceous spot near base.

♂. Unknown.

INDIA: Bangalore, Mysore, four specimens from the larva of *Nyctemera laticinia*.

Easily separated from *E. manilae* and *E. koebelei* by the row of pits at the base of the metathorax being covered by the scutellum; *E. manilae* has the pedicel distinctly shorter than the first joint of the funicle; *E. koebelei* is larger, more robust, and has the legs distinctly reddish.

CRAWFORD, J. C., Philippine J. Sci., Ser. D., **9**, 1914, p. 463.

Euplectrus flavescens, Crawl.

♀. Length 2.5 mm. Yellow; middle lobe of mesoscutum, middle of scutellum, sides of axillae and of metanotum, most of propodeum and pleurae reddish honey-color; the abdomen more or less suffused with the same color; antennae brown, the scape and pedicel testaceous; joints of the funicle elongate, the first over twice as long as the pedicel, the club not longer than the last joint of funicle; pronotum and mesonotum irregularly rugose; the rugae of scutellum finer than on mesoscutum; scutellum at base with two large foveae; metanotum with a median longitudinal carina and on each side of it about two similar but indistinct carinae, the apical margin subcarinate; basal lip of propodeum strongly produced; propodeum with a median and lateral carina, being areolated; legs yellow, the hind coxae slightly tinged with reddish, first joint of hind tarsi almost one and one-half times as long as second joint; longer spur of hind tibiae reaching to apex of second joint of tarsi, the shorter spur about three-fourths as long as first joint.

♂. Unknown.

PHILIPPINE IS.: Luzon, Laguna, Los Baños (C. F. Baker).

The complete areolation of the propodeum distinguishes this from the other species of the Oriental region in which yellow is the predominating color.

Euplectrus rugosus, Crawl.

♀. Length about 2.5 mm. Black, the coxae dark brown, the femora reddish honey-color, rest of legs testaceous; antennae light brown, the scape whitish; joints of the funicle elongate, the first almost twice as long as pedicel, the club slightly longer than last joint of funicle; pronotum and mesoscutum finely rugulose, the axillae finely reticulately lineolate, the scutellum coarsely irregularly rugose, the

apical margin subcarinate ; metanotum with a short median carina extending caudad about half the length of metanotum then dividing and each branch extending laterad then caudad again, making a median apical fovea ; propodeum with a median carina, the basal lip not very strongly produced ; first joint of hind tarsi not quite one and one-half times as long as second, longer spur of hind tibiae reaching almost to apex of second tarsal joint, shorter spur reaching about to base of apical fourth of first joint of tarsi.

♂. Unknown.

PHILIPPINE IS. : Luzon, Laguna, Los Baños (*C. F. Baker*).

This species resembles *E. bussyi*, Crawf., from Sumatra, but in that species the metanotum is smooth, the sculpture of the middle lobe of the mesoscutum is similar to, and almost as strong as, the sculpture of the scutellum, being in both cases reticulately rugose, whereas in *E. rugosus* the sculpture of the middle lobe of the mesoscutum is much finer and of a different type than that on the scutellum.

ROHWER, S. A., Ann. Mag. Nat. Hist., (9) **7**, 1921, p. 135.

Euplectrus euplexiae, Rohw.

♂. Length 1.5 mm. Head polished, with a few fine aciculations on the front ; ocelli small, widely separated from the eye-margins, the ocellular line longer than the interocellar line and two-thirds as long as the postocellar line ; antennae short, the scape as long as the first two funicle joints, funicle joints subequal in length ; transverse carina on pronotum not sharply defined, behind it the pronotum is smooth ; mesoscutum without a median line, irregularly reticulate ; axillae smooth ; scutellum finely reticulate medianly, reticulato-lineate laterally ; propodeum shining, median furrow distinct, complete ; propodeal spiracle close to lateral sulcus ; petiole granular, slightly longer than wide ; abdomen polished ; longer spur of hind tibiae subequal in length with two basal tarsal joints. Black ; head below antennae, frons along eye-margins to near top of eye, antennae, large spot on tergites occupying most of basal part and most of sternites yellowish white ; legs entirely whitish ; wings hyaline, with whitish venation ; body-bristles pale brown.

♀. Length 2 mm. Agrees with male, except for absence of marks on frons, the presence of a distinct yellowish tinge to legs basally, and in having the tergites yellowish dorsally, except for a transverse brownish band before apex.

SOUTH INDIA : Coimbatore, 2 ♀ 1 ♂, 8.xi.1914 (*Ramakrishna Ayyar*), parasitic on *Euplexia conducta*.

MANI, M. S., Rec. Ind. Mus., **37**, 1935, p. 257.

Euplectrus himalayaensis, Mani.

♀. 2.5 mm. long. Body black. Head smooth, with a breadth about two-fifths the height, sparsely covered with long, slender, stiff hairs. Antennae dark brown, inserted low down below the level of an imaginary line drawn from the bases of the eyes, about three-fifths the length of the body ; segments 8 ; scape brown, slender, subcylindrical, with a length about one-third of the funicle, pedicel subcylindrical apically, narrowed basally, with a length about one-fourth that of the scape ; funicle with four segments, first segment with a length about twice that of the pedicel ; second, third and fourth segments nearly equal to each other and each about one-half shorter than the first segment ; club ovate-lanceolate, stouter and a little darker than the other segments, with a length about one-half greater than that of the last segment of the funicle, reduced to a pointed apex, apparently biarticulate. Thorax roughly half the rest of the body, finely and minutely striate, sparsely covered with long hairs ;

scutellum subacutely produced forwards; parapsidal furrows complete and well developed; metathorax with a longitudinal carina in the median line. Fore wings with a length about twice the breadth; submarginal vein about two-thirds the length of the marginal vein; postmarginal vein about twice the length of the stigmal vein and about equal to the submarginal vein. Fore coxa reddish brown, other parts of the fore legs brown. Mid legs uniformly brown, their tibiae densely and shortly setose. Hind coxa black basally, reddish brown apically; other parts of the hind legs brown; their tibiae moderately and shortly setose, the outer spur with a length about half that of the tarsus, which latter has rather long setae. Abdomen depressed, black basally, ventrally brown in the middle, seen from above with a length a little greater than the breadth.

INDIA: E. Himalaya, Darjiling, 1 ♂, 8.viii.1909 (*Jenkins*). Type in the collections of Zoological Survey (Ind. Mus.) Calcutta.

We reproduce here, differently arranged, the key of Indian species given by Mani.

1. All legs, including their coxae, coloured yellow or white uniformly.....2
 Legs differently coloured; black, brown, reddish brown or a combination
 of these.....4
 2. Pedicel armed with pairs of long, stout, bristles both basally and apically; legs
 yellow.....*ceylonensis*, How.
 Pedicel unarmed, without bristles.....3
 3. Scutellum punctate, posterior ocelli placed near the margin of the eyes, pubescence
 whitish*leucostomus*, Rohw.
 Scutellum finely umbilicately punctate in the middle, posterior ocelli placed at a
 distance from the margin of the eyes, pubescence brownish...*euplexiae*, Rohw.
 4. Pedicel shorter than the first segment of the funicle.....5
 Pedicel as long as the first segment of the funicle or nearly so...*nyctemerae*, Crawf.
 5. Scape white, segments of funicle unequal; hind coxae uniformly coloured black...
 bussyi, Crawf.
 Scape brown, segments of the funicle subequal; hind coxae black basally and
 reddish brown apically.....*himalayaensis*, Mani
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THE SURVIVAL OF UNFED *PEDICULUS HUMANUS CORPORIS*,
DE GEER (ANOPLURA) AT DIFFERENT TEMPERATURES.

By H. S. LEESON,

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The object of this investigation was to discover the extreme length of life of nymphs and adults of *Pediculus humanus corporis*, de Geer, when starved at different temperatures. It is important to know this for practical reasons. Though it is impossible to complete the experiments as originally designed, it is considered that such information as has been accumulated should be recorded.

Experiments on once-fed 1st stage nymphs recorded by Nuttall (1917) showed that they survived for shorter periods than those shown here; but the present experiments were done with 2nd stage nymphs and there was the difference in technique to take into account. Nuttall's lice were examined at intervals, whereas in this work the lice remained undisturbed at a constant temperature until the experiment finished.

Referring to adult lice, Hindle's records, given by Nuttall (1917), are similar to those here described. He gives the period of starvation that a louse can survive at 30°C. as three days and at 8–10°C. as seven days. Hindle adds that a louse starved for three days at room temperature only feeds with difficulty, and that it is unlikely that a louse starved for a week would be able to feed at all.

Mellanby (1934) records that fed newly-hatched nymphs and adults behave exactly the same when exposed for the same time, that is 1 hour or 24 hours at high temperatures, and Buxton (1940) found that "the temperature fatal to adults (of both sexes) and larvae is the same."

The lice were kept in the dark at constant temperatures in small petri dishes inside closed desiccators. The bottoms of the dishes were provided with rough surfaces by attaching some coarse black material and loose pieces of tape. Relative humidity was controlled by sulphuric acid and water mixtures. Most of the experiments were done at 90 per cent. R.H. and a few at 65 per cent. The desiccators were opened only at the end of each experiment; this is an important point, for it means that the lice were not disturbed by a daily examination.

Well fed 2nd stage nymphs were used for the first experiments. They were taken from more than one culture and the final numbers in each experiment were gradually built up until they reached 10, 20, or more. The results are set out in Table I and show that a few nymphs live for nine days at 15°C.; this is the maximum. At higher temperatures they live for shorter periods. They also appear to be able to survive only seven days at 10°C., but survival at temperatures below 15°C. needs further investigation. There is much inconsistency between results obtained at 8° and 10°C. In the only instance (24°C.) where alternative humidities can be compared no difference in survival times occurred.

In the second series of experiments well fed adults were used; the same procedure was adopted as with the nymphs. The results include lice of all ages and both sexes (Table II).

By comparing the tables it will be seen that the times taken to kill all adults at certain constant temperatures are almost exactly the same as those taken to kill all nymphs. The times are as follows:—

		<i>Nymphs</i>	<i>Adults</i>
35°C. ...	...	2 days	3 (? 2) days
30°C. ...	...	3 "	3 "
24°C. ...	...	5 "	5 "
23°C. ...	...	6 "	? "
15°C. ...	...	10 "	9 "
10°C. ...	...	7 "	7 "

TABLE II.

Survival of well fed adults of Pediculus starved at certain temperatures (all at 90 per cent. R.H.). Figures above the lines indicate number of survivors. Figures below the lines the number of lice used.

Degrees C.	Days												No. used
	1	2	3	4	5	6	7	8	9	10	11	12	
35	$\frac{1}{12}$		$\frac{0}{4}$										16
30	$\frac{10}{10}$	$\frac{10}{10}$	$\frac{0}{10}$	$\frac{0}{10}$									40
24	$\frac{10}{10}$		$\frac{6}{6}$	$\frac{2}{13}$	$\frac{0}{9}$								38
15	$\frac{19}{19}$	$\frac{30}{31}$	$\frac{18}{18}$	$\frac{25}{26}$	$\frac{15}{28}$	$\frac{11}{24}$	$\frac{10}{40}$	$\frac{2}{29}$	$\frac{0}{31}$	$\frac{0}{5}$	$\frac{0}{6}$	$\frac{0}{13}$	270
10		$\frac{12}{12}$	$\frac{2}{2}$	$\frac{7}{7}$	$\frac{8}{8}$	$\frac{6}{8}$	$\frac{0}{16}$						53
Total No. used	417

THE ECONOMY OF A TSETSE POPULATION.

By C. H. N. JACKSON, D.Sc.

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This short paper summarises and discusses the entomological results obtained from marking experiments done with *Glossina morsitans* at Kakoma, Tabora, Tanganyika Territory, from July 1938 to May 1940. The first eighteen months' data and results have been given in full elsewhere (Jackson, 1941) and the mathematical treatment explained. The marking experiments occupied three days weekly, and covered an area of 16 square miles of annually fired woodland and seasonal swamp; a similar area was observed in the same way for a year in country protected against fire, and in addition a number of special experiments to check results were carried out. The climate and situation of Kakoma have already been described (Jackson, 1937) for the year 1935; from that year until April 1938, smaller scale routine marking experiments were carried on with few interruptions, so that there is available a fairly complete body of data collected over nearly five and a half years.

Length of Life.

All the results are obtained from marked flies. It will appear below that at least the males marked do not live so long as unmarked individuals; nevertheless, interesting results have been obtained from the observations.

Life is shortest in the hottest and driest time of year, when the average male may live only 2 weeks. At such times, no appreciable proportion of individuals survives long enough to die of old age or failing powers, but death is almost entirely due to chance, probably failure to meet with food sufficiently often. (We already know (Jackson, 1937) that flies must feed every fourth or fifth day at such times.) It follows that at the height of the dry season a just-emerged fly has no greater expectation of life than an individual that has already survived a week or two.

In the rains and for a short period after them, life is very much longer, averaging 5 or 6 weeks for males. In these months, many flies die of old age or failing powers, though death by chance (predation?) is still an important factor.

In the dry season, fortunate males may live upwards of 6 weeks; in the rains they may live for 20 weeks or more. At all times females live substantially longer—possibly twice as long. It follows that the female population is perhaps twice as great as the male.

Birth (Emergence) Rate.

Over short periods, this agrees with the death rate fairly closely, for (with the number of births unchanged) a rise in the death rate must produce a rise in the birth rate also. It is consequently difficult to detect seasonal variation in reproduction. We know, however, that when temperature is lower a longer time will be spent in the early stages; that flooding must destroy pupae; and that semi-starvation probably causes abortion in the dry season.

It is established that the percentage of young flies in the catches, or more precisely, the percentage of recognisably young individuals in the total catch of male flies, is a good index of the birth rate.

Dispersal.

Flies of both sexes live in more or less restricted ambits, in which they move freely. These ambits are determined by the disposition of the vegetation, the flies congregating along the contact line of woodland and swamp, often in a special interzone including trees not found in either of the other types. The ambit may be entirely closed, as when it lies along the margin of a small swamp surrounded by woodland; or open in two directions, as when it follows the edge of a swamp forming part of a larger drainage system. Even from "closed" ambits, however, there is a slow loss of flies drifting out or being carried into other ambits in which they then take up life as before.

The effect of these ambits is that, though a quarter of the male flies, and a third of the females, will have left the 4×4 mile square in the first week after marking, the net loss of marked flies in later weeks is very small (3 per cent.), because nearly as many flies return as leave. We thus have a constant going and coming within any particular ambit, and a relatively very slow rate of drift outwards from it. It follows that, in the country studied, wandering game animals have very little effect in aiding the dispersal of the tsetses.

The average distance travelled in a week by a male fly is half a mile in either direction from any given straight line. But, because it is forever going and returning within its ambit, the average net distance travelled in its whole life does not greatly exceed half a mile.

In this to-and-fro movement, chance re-immigration of course plays a contributory part, but this is unable to account for much of the centripetal tendency observed.

The females have rather larger ambits than the males, possibly because they penetrate farther from the contact line into the undifferentiated woodland bordering the swamps, whether in order to deposit larvae or to avoid inopportune males.

Neither the size of the ambits, nor the slow rate of drift away from them, varies much with season.

There is no doubt that flies congregate along these contact lines in order to satisfy their need for *vegetational concurrence* (Swynnerton, 1936). The swamp or interzone provides good visibility and attractive conditions for food animals, and is therefore a feeding ground (Jackson, 1931); while the shadier woodland near by forms the breeding and resting haunt, or home. It has already been shown that the flies move under the stimulus of hunger from the home to the feeding ground.

Population.

The ambit effect, and effects arising from the fact that death from old age in the rainy season alters the shape of the survival curves, invalidate estimates of population previously given. The ambit effect tends to reduce the previous estimates, but this is more or less counteracted in the rainy season, when the survival curves depart from the geometric form.

Revised estimates show that the population averages just about 1,000 male flies to the square mile, and there are perhaps twice as many females.

Activity.

The activity of the flies—their readiness to appear to the catchers—is highest in the first half of the rainy season, and lowest at the hottest time of year. At any one season, numbers caught are usually a good index of actual density of population.

In these experiments about a dozen males were caught per linear mile.

Effect of Excluding Fire.

In the one year in which this was observed, the population fell in the fire exclusion area, while it rose in the control, until the middle of the rains. This was caused by a fall in the birth rate in the fire exclusion area, where flies continued to live as long as in the control. By the middle of the rains population was three or four times denser in the control square.

Thereafter, population in the fire exclusion rose slowly until by the end of the year it about equalled the control. This rise was caused by increase in the birth rate in the fire exclusion to equality with that of the control, coupled with longer life in the fire exclusion.

The work of my colleague, Mr. John Ford, strongly suggests that the low birth rate in the fire exclusion area at the end of the dry season and through the early rains is attributable to increased destruction of the pupae by ants (*Pheidole*) in the fire exclusion at that time.

Effect of Marking.

As stated above, the length of life of marked flies is less than that of flies unmarked.

By releasing flies, unmarked and marked with oil paints, in an area where the species does not occur naturally, it has recently been shown that the unmarked flies survive significantly longer. Further, use of handled and unhandled flies showed that the difference was not caused by the handling incidental to marking.

Nor, apparently, is the effect explained by any direct lethal action of the paints, for Mr. W. H. Potts has shown that very large numbers of captive, painted flies survived as long as unpainted controls kept under identical conditions.

Colours (black, purple) which are to human eyes less conspicuous than others (light blue, etc.) do not appear to increase survival of flies released.

The weight of paint applied is ordinarily from 0.5 to 2.0 mgm. depending upon how many times the fly is re-marked; and this, it is supposed, can have little effect.

The adverse action of painting the flies therefore remains unexplained at present. All that can be said is that the lengths of life quoted above are less than those ordinarily obtaining among unmarked flies in nature.

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A NEW MEALY BUG ATTACKING PINEAPPLE PLANTS IN MAURITIUS.

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The pineapple plantations of Mauritius have sustained since 1937 severe attacks of mealybugs (*Pseudococcus* spp.) which threatened to ruin the whole crop in certain localities. These attacks result in a wilting of the plants, which may be due to a toxin secreted by the bugs during their process of feeding.

The Entomological and Plant Pathological Divisions of the Department of Agriculture, working in full cooperation, succeeded in reducing this infestation by using radical measures, such as the spraying of the plants with a locally made and tested insecticide. An interesting leaflet on this matter has been published by Messrs. W. F. Jepson and P. O. Wiehe.

Dr. W. F. Jepson, the Entomologist of the Department of Agriculture, who suspected that there might be other bugs associated with *Pseudococcus brevipes* (Ckll.) on pineapple in Mauritius, collected a large number of *Pseudococcus* from diseased and healthy plants in different localities of the island. He handed them over to me for the study of those morphological characters which might help to solve the problem. After carefully examining the individuals submitted to me, I have come to the conclusion that there are two species confused under the name of *P. brevipes* on pineapple in Mauritius. These species are *P. brevipes* (Ckll.) and another, apparently new, which I am describing below under the name of *P. pseudobrevipes*, sp. n.

My thanks are due to Dr. Jepson for his kindness in entrusting this work to me.

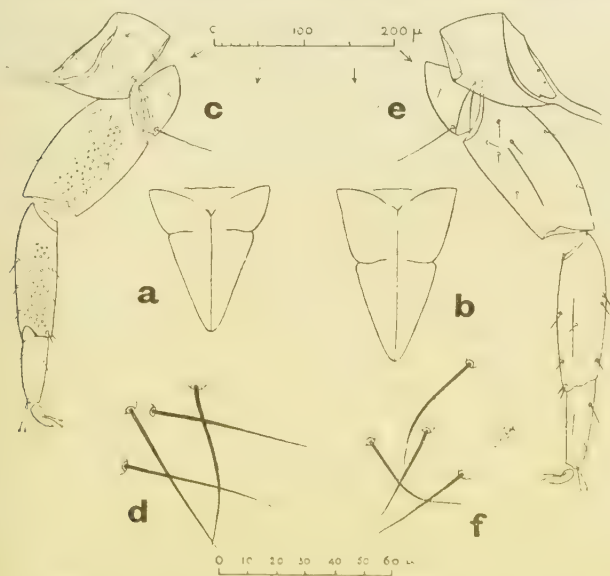


Fig. 1. *Pseudococcus pseudobrevipes*, sp. n.: (a) mentum; (c) hind leg; (d) dorsal setae prior to anal ring.
Pseudococcus brevipes (Cockerell): (b) mentum; (e) hind leg; (f) dorsal setae prior to anal ring.

***Pseudococcus pseudobrevipes*, sp. n.**

Adult female broadly oval, fairly convex, pale yellowish in colour. Dermis covered with a white, waxy secretion. Margin with a fringe of waxy tassels which tend to be more developed in the abdominal region.

Antennae 6- to 8-jointed, as in *brevipes*. Mentum (fig. 1, *a*) shorter than in *brevipes* (fig. 1, *b*). Limbs stout; hind femora and tibiae with numerous translucent pores (fig. 1, *c*), femur + trochanter (of third leg) shorter than tibia + tarsus (253μ : 261μ). Seventeen pairs of cerarii; all with stout auxiliary setae, fairly numerous trilocular pores and with 1 to 4 cerarian spines. There is some variation in regard to the number of cerarian spines, but, in general, the arrangement is as follows:— I (anterior), 3-4; II, 2-4; III, 2-3; IV, 2; V, 2; VI, 2-3; VII, 2-3; VIII, 1-3; IX, 2; X, 1-3; XI, 1-3; XII, 2-4; XIII, 2-3; XIV, 3-4; XV, 2-3; XVI, 2-3; XVII, 2. No sclerotised area about any of the cerarii except a fairly indicated area about those of the anal lobes. Ventral side of anal lobes with a large irregular quadrate, sclerotised area. Dorsal body setae fairly stout. A loose band or cluster of slender setae, varying in length from 45μ to 70μ , with an average of 55μ (fig. 1, *d*) present immediately anterior to anal ring dorsally, while in *brevipes* these setae average 40μ in length (fig. 1, *f*). Anal lobe seta approximating 137μ in length, while in *brevipes* it approximates 148μ . Anal ring setae about 90μ in length. The usual trilocular pores present on both dorsal and ventral dermis. Pores with short tubular ducts present on the ventral surface of the three abdominal segments prior to vulva. Multilocular disc pores present near the vulvar area. Dorsal and ventral ostioles normal.

Length, 1.5-2.2 mm.; breadth, 1.4-1.9 mm.

MAURITIUS: Montagne Longue, 5 and 8.xii.1938 (*Dr. W. F. Jepson*), on fruits of pineapple plants (*Ananas comosus*) of the "Victoria" variety.

This species is very closely related to *P. brevipes* (Ckll.). The characters which might enable one to differentiate between them can be summarised as follows:—

<i>Pseudococcus brevipes</i> (Ckll.)	<i>Pseudococcus pseudobrevipes</i> , Mamet
1. Very few or no translucent pores on femur and tibia of 3rd leg.	Numerous translucent pores on femur and tibia of 3rd leg.
2. Tibia + tarsus (of 3rd leg) equal to femur + trochanter (267μ).*	Tibia + tarsus (of 3rd leg) longer than femur + trochanter (261μ : 253μ).
3. Mentum averaging 200μ in length.	Mentum averaging 178μ in length.
4. Anal lobe setae averaging 148μ in length.	Anal lobe setae averaging 137μ in length.
5. Dorsal setae just prior to anal ring approximating 40μ in length.	Dorsal setae just prior to anal ring approximating 55μ in length.
6. Anal lobe cerarii fairly sclerotised; the two cerarii prior to them faintly sclerotised.	Anal lobe cerarii fairly sclerotised; the two cerarii prior to them not sclerotised.

Near to *P. cannae*, Green, from which it differs by the stouter limbs and antennae.

This species is also related to *P. probrevipes*, Morrison, from which it differs by the shape of the sclerotised area of the anal lobe ventrally and the length of the setae situated just prior to the anal ring dorsally (55μ in *pseudobrevipes* as compared with 14μ in *probrevipes*).

Key to Adult Females of *Pseudococcids* collected on Pineapple throughout the World.†

1. With only the anal lobe cerarii present.....*Trionymus sacchari* (Ckll.)
Series of cerarii complete, at least 17 pairs present.....2

* These figures are averages of fairly long series of each species.

† I am indebted to Mr. E. E. Green for a list of these species.

2. With 17 pairs of cerarii, some with more than 2 spines, with auxiliary setae ;
ventral sclerotised area of anal lobes quadrate.....3
With 18 pairs of cerarii, each with 2 spines, no auxiliary setae ; ventral sclero-
tised area of anal lobes linear.....4
 3. Hind femora and tibiae with numerous translucent pores ; dorsal setae just prior
to anal ring averaging 55μ in length.....*Pseudococcus pseudobrevipes*, Mamet
Hind femora and tibiae without translucent pores ; dorsal setae just prior to
anal ring averaging 40μ in length.....*Pseudococcus brevipes* (Ckll.)
 4. Tips of cerarian spines and dorsal body setae flagellate.....
Pseudococcus krauhniae (Kuw.)
Tips of cerarian spines and dorsal body setae not flagellate.....
Pseudococcus citri (Risso)
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BIOLOGY OF THE COTTON STEM-WEEVIL, *PEMPHERULUS AFFINIS*, FST., UNDER CONTROLLED PHYSICAL CONDITIONS.

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Agricultural Research Institute, Coimbatore.

1. Introduction.

There seems to be scarcely any need to stress the importance of the study of the physical ecology of *Pempherulus affinis*, Fst.* Any studies on an economic insect should begin with the investigation of its climatic environment (Uvarov, 1931). *Pempherulus* is a well-known destructive stem-boring weevil of cotton in South India. Its control has been an admittedly difficult problem on account of its habit of living in protected situations which precludes the adoption of ordinary control measures. A knowledge of the effects of climate on the several stages of the weevil is therefore most important in affording clues for devising effective measures of control.

The imperative need for such a study was, however, not brought home until the senior author had made some distributional studies in the latter part of 1936, both in this and in a few other provinces in India, and the junior author had made intensive studies in one of the southern districts, namely Ramnad, with regard to an investigation into the factors that are responsible for the presence or absence of the pest in cotton under particular situations. In the course of these studies, it was apparent that the distribution, activities, abundance and absence of the pest in certain situations and regions, as also its seasonal variations, presented problems very difficult of explanation in the absence of any knowledge of the insect's reactions to climate. Beyond some theoretical notions based on scattered, inexact field observations, no definite data were available. Therefore, early in 1937, a preliminary investigation into the weevil's responses under controlled conditions of temperature and moisture was started. The study is still in progress and is admittedly incomplete. An attempt, however, is made here to present the results so far obtained with a view to emphasise the need for further studies in the same line.

The early history of the insect begins with its initial association with an exotic variety of cotton, namely Cambodia; and its area of distribution was at the time restricted to Coimbatore (Fletcher, 1913). Other varieties, such as the indigenous ones, were supposed to be entirely free from its attentions (Ballard, 1922). The area of its distribution soon extended to most of the southern districts of the province, such as Madura, Ramnad and Tinnevely, and this was attributed to the spread of cultivation of Cambodia cotton.

As a result of field studies made by the authors, it has been discovered that its depredations are sometimes equally heavy in country cottons, suggesting that cultural operations are perhaps of more consequence in its incidence than varietal differences. The irrigated cottons usually show heavy infestations, but when sown dry, the incidence is seen to be light.

The several regions comprising its area of distribution have a variety of climates. It is observed to occur in extremely moist districts, like Malabar, and dry arid districts, like Tinnevely and Ramnad. It also occurs in Behar, Dehra Dun (United Provinces),

* This species, known hitherto as *Pempheres affinis*, has been transferred to a new genus, *Pempherulus*, Mshl. (Ann. Mag. Nat. Hist. (11) 7, 1941, p. 194).—Ed.

and Guzerat. It is entirely absent from Hyderabad. These considerations, coupled with quantitative and field data gathered, raise points of great practical importance which call for experimental evidence. Therefore the following series of experiments under controlled conditions of temperature and moisture was started with a view to obtaining definite data. The data so far gathered seem to indicate that it has very definite requirements of moisture and temperature, not only for the adults, but also for each phase of its development.

2. Technique.

In conducting these experiments, the difficulty lay in devising a suitable technique for experimenting with a stem-borer. The following method was found to be the best in the circumstances. The temperature was controlled by means of electric incubators and the degree of humidity by a series of sulphuric acid solutions. Mixtures of sulphuric acid and water were prepared to give a series of relative humidities with the aid of curves published by Buxton (1931) and Wilson (1921). The relative humidities provided ranged from an extremely dry atmosphere (approximating 0 per cent.) to saturation in a regular series of 0 per cent., 20 per cent., 40 per cent., 60 per cent., 80 per cent. and 100 per cent. relative humidities. Pure sulphuric acid and distilled water were used for the extremes of humidities. Since the weevils experimented with were very minute in size, the apparatus used consisted of glass tubes 6 in. \times 1 in., similar to those employed by Ulyett (1936). A partition in the shape of a tight circular ring of cork with a thin muslin covering was provided in the middle of the tube, dividing it into an upper and lower compartment. In the bottom half of the tube was kept an ample quantity of the mixture giving the required humidity; and the weevils were introduced into the upper half. The tube was kept tightly closed by paraffined corks and was placed in the desired temperature in the incubator. In a few cases food (a small raisin) was fastened to the bottom of the cork. The presence of the raisin had very little effect on the humidity of the atmosphere as a whole. The mixtures for humidities were renewed every day and were not kept exposed for more than the minimum time required for examination. For trials in oviposition and development of immature stages, a small bit of fresh cotton stalk (less than an inch in length) was introduced into the tube. This might appear to disturb the humidity, but on actual experiment and calculations after 16 hours, the effect was found to be slight and negligible. It is admitted that the humidities referred to in the experiment are not absolutely exact but approximate to the percentages indicated.

3. Adult Longevity in Relation to Temperature and Varying Humidities.

The effects of varying temperatures and humidities on the duration of adult life were tested in a series of experiments. These were intended to shed light on the limits within which life and normal activity are possible, since these factors largely determine the degree of adjustment of the species to its habitat. The experiments were conducted with males and females, mated and unmated, fed and unfed, and mated females allowed to oviposit and otherwise. These data are important to ascertain the possibility of survival of the species during spells of extreme hot weather.

1. At 122° F. Constant Temperature.

A series of trials was made at this temperature with different humidities with a supply of raisin as food, and the results are recorded in Table I. Out of 83 adults, 13 were stupefied by the end of the first hour; 41 were stupefied by the end of the second hour; 13 by the end of the third hour; and 16 at varying intervals beyond the third hour.

TABLE I.

Humidity	No. of adults tried	No. stupefied			Stupefied beyond three hours	Results of six hours exposure
		Hours				
		1	2	3		
0	14	2	5	—	7	None revived
20	14	5	7	1	1	.. ..
30	14	—	5	2	7	.. ..
60	14	4	5	4	1	.. ..
80	13	—	10	3	—	.. ..
100	14	2	9	3	—	.. ..

After exposure for six hours, none of the adults revived on removal to laboratory temperature, though kept under observation for 2 days; whereas the majority revived when removed after 2 hours' exposure. Stupefaction and death occurred similarly at this temperature with or without food, and with or without a cotton stalk for oviposition. Six hours' exposure caused actual death beyond recovery, and it may be that a shorter time might have been sufficient to kill them in a still higher temperature; but such high temperatures do not occur within the range of distribution of the species. Humidities seem to have little influence in affecting viability at this temperature; in fact, the higher humidities seem to operate adversely and to shorten life.

2. At 113°F. Constant Temperature.

Mated females fed and allowed to oviposit.—The duration of life is considerably shortened in all humidities at this temperature, varying from 46 to 50 hours. The humidities have had no influence on the longevity, as the temperature is far beyond the vital zone. The following curve (fig. 1) presents the results of the trial.

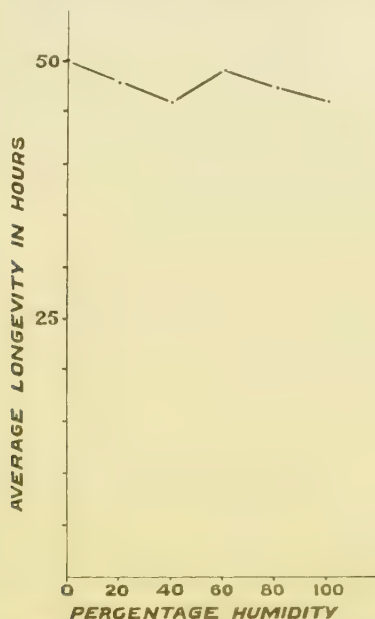


Fig. 1. *Pemphorus affinis*, Fst.: longevity of female, mated—allowed to oviposit—with food. Constant temperature of 113°F. and varying humidities.

3. At 100°F. Constant Temperature.

Unfed mated females not allowed to oviposit.—The maximum average longevity of the mated female without food proved to be 3.7 days in a relative humidity of 80 per cent. ; longevity in 100 per cent. R.H. was 3.3 days, and this figure is higher than those in other humidities, showing that 100 per cent. R.H. is not so unfavourable here as at higher temperatures. The curve (fig. 2) representing the results also shows that 100 per cent. R.H. is apparently nearer the optimum than 60 per cent. R.H.

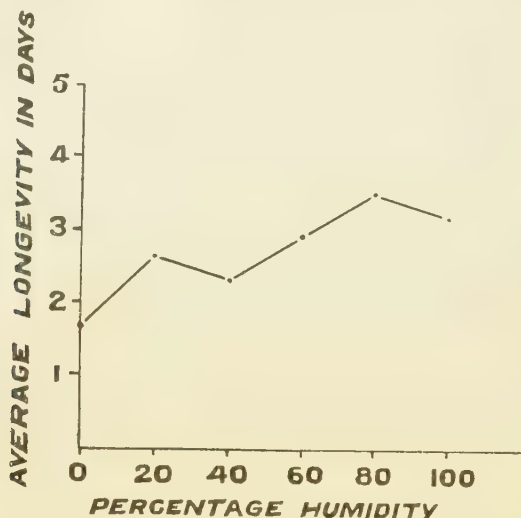


Fig. 2. *P. affinis*, Est. : longevity of female, mated—not allowed to oviposit—without food. Constant temperature of 100°F. and varying humidities.

Unmated females without food.—The maximum average longevity at 100°F. was 3.7 days, which was reached in a saturated atmosphere. The longevities in 0 per cent., 60 per cent. and 80 per cent. R.H. were 2, 3.3 and 3.4 days, respectively. There is thus a gradual lengthening of the duration of life as humidity increases from an extremely dry to a saturated atmosphere, showing that at 100°F. a saturated atmosphere is nearer the optimum.

Mated males without food.—In this case the longevity curve at 100°F. is a gradual rise from 1.5 days in 0 per cent. R.H. to 3.8 days in 100 per cent. R.H., which appears to be the optimum humidity.

Unmated males without food.—The longevity at 100°F. again gradually rises from 1.9 days in 0 per cent. R.H. to a maximum of 3.7 days in 100 per cent. R.H., which condition seems to be the optimum.

Mated females with food and not allowed to oviposit.—At 100°F. the results showed a gradual upward trend from 2.0 days in 0 per cent. R.H. to 4.1 days in 40 per cent. R.H., with a sudden and steep rise to 19.6 days in 60 per cent. R.H., attaining a maximum longevity of 20.6 days in 80 per cent. R.H. This was followed by a fall to 11.7 days in 100 per cent. R.H., the optimum condition being in 80 per cent. R.H.

Unmated females with food.—The effect of humidity at 100°F. is here quite evident by a rise in longevity from 2.0 days in 0 per cent. R.H. to 6.8 days in 40 per cent. R.H., with a sudden rise to 13.8 days in 60 per cent. R.H. and 19.4 days in 80 per cent. R.H.,

wherein the maximum was attained. There was then a marked fall to 10 days in 100 per cent. R.H.

Mated males with food.—The longevity curve at 100°F. in this case showed a gradual rise from 2.0 days in 0 per cent. R.H. to 7.8 days in 60 per cent. R.H., whence it suddenly made a sharp rise to 23.3 days in 80 per cent. R.H., falling to 18 days in 100 per cent. R.H.

Unmated males with food.—The longevity records at 100°F. showed a rise from 2.0 days in 0 per cent. R.H. to 3.0 days in 40 per cent. R.H. the duration in humidities 60 per cent., 80 per cent. and 100 per cent. being 9.0, 11.6 and 11.1 days, respectively, with the maximum as usual in 80 per cent. R.H.

Mated females without food allowed to oviposit.—In a few cases where food or a stalk was introduced, marked irregularity in results was noticed. This is a typical instance where the curve is very erratic. At 100°F., 0 per cent. R.H. showed a longevity of 5 days, 20 per cent. R.H. and 40 per cent. R.H. had 4 days each, 60 per cent. R.H. had 6 days, with a fall to 5 days in 80 per cent. R.H. and 4 days in 100 per cent. R.H., the maximum being attained in 60 per cent. R.H., as shown in the curve (fig. 3). This shifting of the maximum is probably due to the disturbance of the conditions by the physiological process of oviposition.

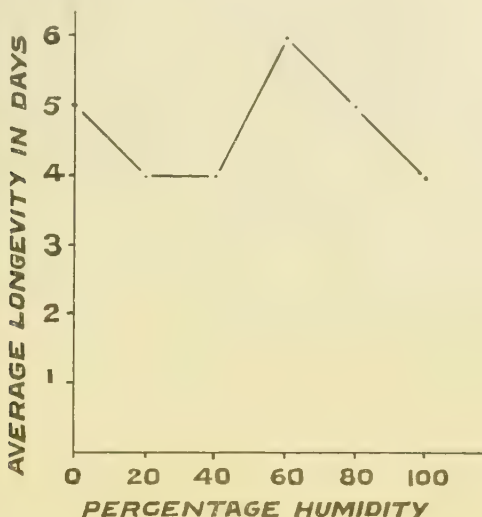


Fig. 3. *P. affinis*, Fst.: longevity of female, mated—allowed to oviposit—without food. Constant temperature of 100°F. and varying humidities.

Mated females with food allowed to oviposit.—The data obtained in this case are based only on a few trials, the curve being very abrupt and erratic. The longevity at 100 F. and 0 per cent. R.H. was 18.7 days; the maximum longevity was attained in 20 per cent. R.H. with 21.7 days, the higher humidities of 60 per cent. and 80 per cent. showing about 9 days, with a fall to 7 days in 100 per cent. R.H. The data are highly abnormal in humidities 0 per cent., 20 per cent. and 40 per cent. and admit of no easy explanation.

They may possibly be explained by the fact that "very high humidities may be injurious through preventing evaporation, which tends to lower the body temperature

and thus moderate the influence of heat" (Uvarov, 1931). The longevity is greater in a lower humidity if fresh food in the shape of raisin is supplied with a high water content, which compensates for the loss of body moisture in a drier atmosphere. This may be advanced as the general reason for a lower humidity being more favourable in cases with a supply of food. This inference is largely supported by Uvarov (1931) and Buxton (1937). There are direct indications that the water obtained with food may make an insect practically independent of the atmospheric humidity.

4. At 93°F. Constant Temperature.

Field observations seem, in a general way, to indicate that maximum efficiency of population in this species under field conditions in Coimbatore is attained when the mean temperature is in the neighbourhood of 93°F. The trials under this and lower temperatures are therefore of particular interest.

Mated females without food and not allowed to oviposit.—There was a gradual increase in longevity from 2.1 days in 0 per cent. R.H. to 4.6 days in 80 per cent. R.H. and a fall to 3.3 days in 100 per cent. R.H., the longevity in 100 per cent. being equal to that attained in 40 per cent. R.H. Saturation seems to facilitate greatly the growth of fungus.

Unmated females without food.—An average longevity of 2.1 days in 0 per cent. R.H. gradually rises to a maximum of 4.4 days in 80 per cent. R.H., whence it decreases to 3.4 days in 100 per cent. R.H.

Mated males without food.—The data recorded in the curve (fig. 4) are somewhat irregular in these cases. There was an increase in longevity from 2 days in 0 per cent. R.H. to 3.1 days in 40 per cent. R.H.; 60 per cent. R.H. showed a fall to 2.8 days, which is rather unusual, the optimum longevity of 3.3 days being attained in 80 per cent. R.H. A saturated atmosphere has the same effect as the dry condition of 40 per cent. R.H.

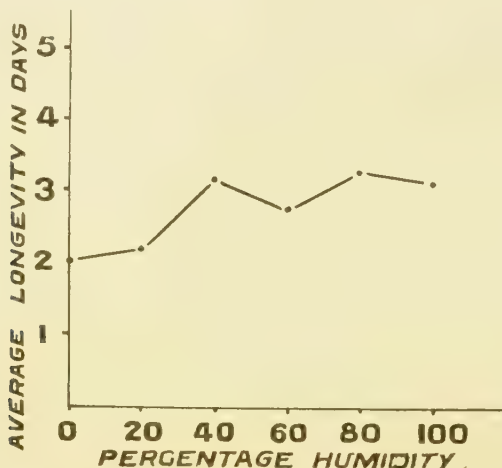


Fig. 4. *P. affinis*, Est.: longevity of male, mated—without food. Constant temperature of 93°F. and varying humidities.

The longevity of males in general is always less than that of females, whether mated or unmated, without food. The maximum average longevity in the female is 4.6 days in 80 per cent. R.H., whereas it is 3.3 days in 80 per cent. R.H. for the mated male.

Unmated males without food.—An erratic trend is again visible in the curve. The rise was gradual from 2.1 days in 0 per cent. R.H. to 3.2 days in 40 per cent. R.H. ; 60 per cent. R.H. seemed to be less favourable, showing a diminished longevity of 3 days. The maximum longevity of 4 days in 80 per cent. R.H. was noticed as usual. Saturation point is not very unfavourable, as indicated by the figure 3.7.

The maximum longevity was 4 days in 80 per cent. R.H. in the case of males, whereas in unmated females it was only 4.4 days in the same humidity. Here the unmated male has a slightly greater longevity than the mated unfed male. Eighty per cent. R.H. seems to be the optimum for unfed adults mated or unmated.

Mated females with food and not allowed to oviposit.—In this case the optimum for longevity appears to be 80 per cent. R.H., where the average rises to 13.5 days. There was not much difference in longevity in the humidities 40 per cent., 60 per cent., 80 per cent. and 100 per cent., the range of variation being only 13 days to 13.5 days.

Unmated females with food.—Here there seems to be a vast difference between the minimum and maximum longevity. In 0 per cent. R.H. there was a minimum of 2.4 days, which showed only a slight rise to 3.5 days in 20 per cent. R.H. The curve (fig. 5) suddenly shows a steep rise from 14.1 days in 40 per cent. R.H. to a maximum of 39.3 days in 60 per cent. R.H. ; 80 per cent. R.H. is not altogether unfavourable as it gives 34.7 days. A saturated atmosphere in this case indicates a fall to 18 days.

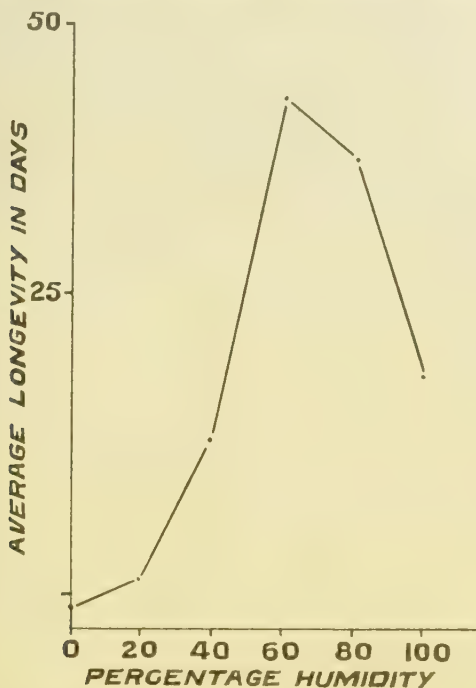


Fig. 5. *P. affinis*, Est.: longevity of female, unmated—with food. Constant temperature of 93°F. and varying humidities.

Mated males with food.—The optimum longevity of 32 days is attained in 60 per cent. R.H., which is far higher than the 4.7 days in 40 per cent. R.H. and 18.5 days

in 80 per cent. R.H. A humidity of 100 per cent. showed as low a duration as 7.9 days.

Unmated males with food.—The curve shows the same trend as in the two preceding cases, gradually rising from 2.7 days in 0 per cent. R.H. to 10.6 days in 40 per cent. R.H., and to 34.7 days in 60 per cent. R.H. From this maximum it assumes a uniform downward trend to 23.9 in 80 per cent. and 23 days in 100 per cent.

Mated females without food and allowed to oviposit.—The data are of considerable interest in this case, because they show no appreciable differences in the various humidities, and graphically the curve assumes an almost straight horizontal course. The difference between the duration of life in optimum humidity and a dry atmosphere of 0 per cent. R.H. is very slight, the average longevity being 6.1 days and 5.5 days, respectively. Atmospheric moisture is of little consequence in this case on account of the metabolic process involved in oviposition. Here also the optimum is about 60 per cent. R.H. with 6.1 days duration of life, though there is no appreciable lowering in 80 per cent. R.H.

Mated females with food and allowed to oviposit.—The longevity here increased to more than threefold with a supply of food, *i.e.* from 6 to nearly 20 days (fig. 6). Barring the abnormal figure in 20 per cent. R.H., the optimum was 60 per cent. R.H., 80 per cent. R.H. being very nearly as good.

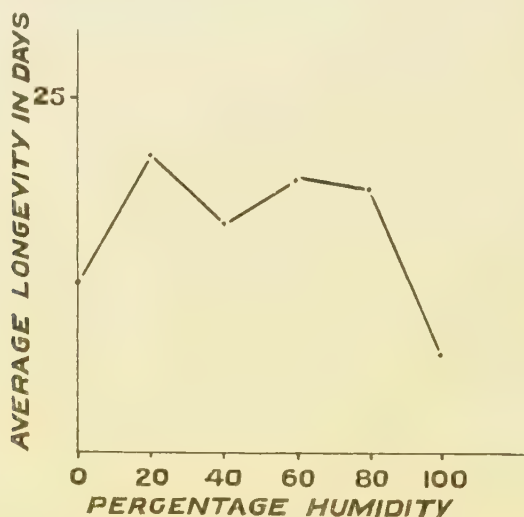


Fig. 6. *P. affinis*, Fst.: longevity of female, mated—allowed to oviposit—with food. Constant temperature of 93°F. and varying humidities.

Marked irregularity is seen in the duration consequent on the supply of food. The insect is less adversely affected by a dry condition of atmosphere in 0 per cent. R.H., 20 per cent. R.H., or 40 per cent. R.H. In fact it seems to create congenial conditions by regulating its moisture requirements through absorption from food in drier conditions; whereas in higher humidities it seems to be at a disadvantage owing to slow evaporation.

5. At 91°F. Mean Temperature and 73 per cent. Mean Relative Humidity.

Mated females fed and allowed to oviposit.—The average longevity, under these conditions, came to 50.5 days with an individual maximum of 121 days for 48 adults

tried. This is a record figure for longevity so far. It is generally recognised that there exists a definite combined optimum of temperature and humidity for each species of insect, as also critical conditions of these factors for every species. Their combined action governs the fluctuations in numbers in a particular locality. In the case of insects with a long life-cycle this optimum combination may vary with each stage of its development, as also for certain phases of each stage. In such cases there exists a condition (within the vital limits or zone) under which maximum efficiency of all activities is attained. It is evident that this combination of 91°F. and 73 per cent. R.H. is the preferred condition for adult longevity, so far as the present range of experiments goes. It may be seen later than this seems to be the optimum for other activities as well.

6. *At different Constant Temperatures.*

Longevity in fed adults is always greater than in unfed ones, because the supply of food is beneficial by affording nutrition and by replenishing the moisture lost by evaporation. There is considerable variation in longevity between the sexes, as also among mated and unmated adults. The unmated females fed in a temperature of 93°F. have generally a longer life than mated ones not allowed to oviposit. At 100°F. there is not much difference between mated and unmated females.

At temperatures above 100°F. humidity seems to have little influence on adult longevity, which decreases proportionately with the increase of temperature from 91°F. to 122°F., the latter temperature being in the neighbourhood of the thermal death-point, as an exposure of six hours effects a complete kill. Probably a slightly higher temperature might reduce the length of exposure even to a few minutes. The maximum longevity was obtained at a mean temperature of 91°F. in combination with a mean humidity of 73 per cent. This longevity was not obtained, so far as the present trials go, in any other temperature-humidity combination. At 93°F. the average in the most favourable humidity, namely 60 per cent., was only 39.3 days. At 100°F. the maximum longevity attained in 80 per cent. R.H. was 20.6 days for females mated and with food but not allowed to oviposit, and 23.3 days for mated males. At 113°F. the longevity was reduced to two days, with little differentiation among the different humidities.

Difference in longevity between fed and unfed is marked on account of the moisture in the food. Even when fed, the longevity is markedly low in drier atmospheres (namely, in 0 per cent., 20 per cent. and 40 per cent. R.H.) in the majority of cases, for the insect gives out moisture in large quantities under such conditions. In adult insects having a hard chitinous covering, moisture loss may probably be effected through the spiracles and by excretion, rather than through the surface. Immature stages, such as grubs which are soft-bodied, must be far more susceptible and sensitive than adults.

7. *At variable Temperatures and Humidities.*

From an examination of the data analysed, as shown in the curve (fig. 7), there is a gradual decrease in longevity as the temperature rises from 91°F. to 122°F. in each of the six humidities.

As between the sexes, the longevity does not show much variation in favourable humidities; whereas in unfavourable humidities, such as 0 per cent., 20 per cent. and 40 per cent. in 93°F. and 0 per cent. to 60 per cent. in 100°F., there is a striking difference between males and females, the latter showing a significantly longer life. Even in a higher humidity which is not quite favourable, e.g. 100 per cent. R.H., the same trend may be noticed. In optimum conditions, such as 60 per cent. R.H. in 93°F. and 100 per cent. in 100°F., the life of the male is more prolonged than that of the female.

These show that the humidity requirements of the weevil increase in proportion to the rise in temperature. The optimum, which is between 60 per cent. and 80 per cent. R.H. at 93°F., is shifted to somewhere between 80 per cent. and 100 per cent. with an increase in temperature to 100°F. In regard to unfed adults in 93°F. the optimum is 80 per cent. R.H., whereas in unfed ones at a higher temperature (namely 100°F.) the optimum has shifted to 100 per cent. R.H. In the case of adults fed on raisin, the optimum humidity at 93°F. is 60 per cent. R.H., whereas at 100°F. it has shifted to 80 per cent. Thus the optimum condition of humidity for adults, fed or unfed, in 93°F. lies within the lower limit of 60 per cent. and upper limit of 80 per cent. and 100 per cent. R.H. It has already been pointed out that even in such optimum humidities, the longevity at these temperatures is not comparable with that obtained at 91°F., where a record length of life (namely an average of 50.5 days) was noted. Since 93°F. and all temperatures above have shown a shorter life even under optimum conditions of humidity, it may be concluded that 91°F. is probably the optimum temperature for the weevil, as seen within the present range of trials.

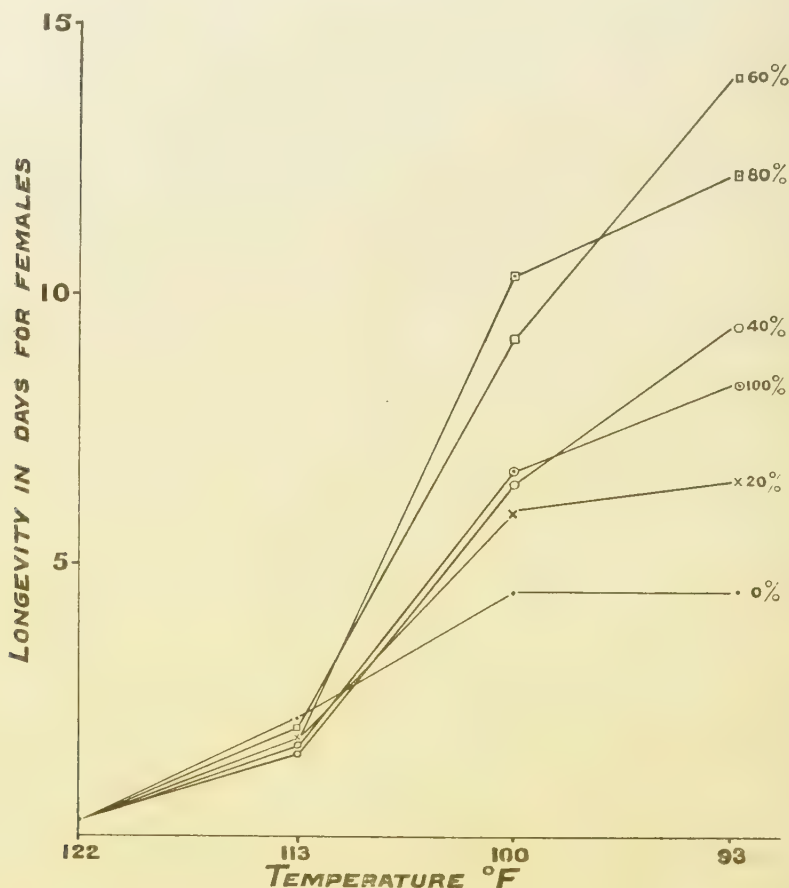


Fig. 7. *P. affinis*, Fst.: longevity of females—with food—at different temperatures and humidities.

4. General Biology of the Adult.

In the course of these studies it was found that very little was known on some essential aspects of the biology of the pest. A knowledge of these was deemed absolutely necessary to afford us a proper basis for understanding and interpreting the results obtained under controlled conditions, particularly in regard to oviposition and the differential requirements of the various stages of the weevil. The results of these studies are presented here briefly.

Emergence of adults.—The period of emergence continues up to a maximum of over two months. This prolonged period is of significance since the pulled-out cotton stalks could form a potent nucleus for reinfestation of the succeeding crop and also serve as a medium for bridging the off-season. A lengthened emergence period is seen to be brought about by uneven development of the mature grubs, which continue as such for a prolonged period owing to either insufficient nutrition or extreme dryness or dampness of the stem. Emergence was found to be at its peak between 11 a.m. and 2.30 p.m., and did not occur at all during the early hours.

Reactions to light.—The adults are highly sensitive to daylight, as seen from their sudden flights to lighted portions of cages. They are in a position to perceive even slight variations in the intensity of light. They have, however, not been attracted to artificial lights at night. It is also surprising that, in spite of their attraction to lighter positions during the day, they are seldom found resting on plants in the field.

Proportion of sexes.—Out of a total of 8,886 adults that emerged during the years 1932, 1933, 1937 and 1938, whose sexes were noted, there were 5,034 females and 3,852 males, giving a percentage of 56.7 females and 43.3 males. The females are always slightly in excess of males, although there is considerable variation in the course of daily emergences among the different lots. A marked preponderance of either females or males occurs in the initial and closing periods of emergence. An equilibrium of sexes is often noted in the intervening period.

Feeding behaviour.—Little is known regarding the food habits of the adult, but it generally feeds on the bark of the plant. The preferred sites of feeding are near the nodes, which are more succulent.

Mating.—Copulation commences immediately after emergence from the stems, as has been observed in hundreds of cases in cages as well as in nature. Mating activity is seen at its maximum during midday, when bright sunshine prevails, in consonance with the increased general activity of the adults at this time of the day. Copulation may take place several times at frequent intervals even with adults nearly two months old.

Duration of fertility.—In order to test whether frequent matings are necessary to fertilise eggs at intervals, a set of 23 females was isolated after mating for a day or two. Such females continued to be fertile for long periods. It was seen that eggs laid by a female 67 days old hatched normally. The maximum egg-laying period so far noted was 78 days, the average period being 37.6 days. A batch of 22 females was also kept in company with males so as to allow of frequent mating till death. The average egg capacity in this case was found to be 44.1 eggs per female, as against 47.7 of the former lot. The duration of the egg-laying period averaged 38.5 days, as against 37.6 days of the former, and the average longevity was 50.7 days, as against 50.2 of the previous lot. These data therefore go to show that frequent matings or early separation do not materially affect the egg capacity, egg-laying period or longevity of females.

Parthenogenesis.—This did not occur in this species, although it is stated that the phenomenon is occasionally found in Curculionids (Dick, 1937). A series of experiments with virgin females has shown that there were no egg-layings except in a solitary instance, when a single egg was laid externally on the surface of a stalk at the cut end.

The egg.—The egg is variable in shape, depending on pressure exerted during deposition. It varies within a wide range from globular to oval or cylindrical. The newly laid egg is turbid or milky white in colour and glistening under diffused light. It is uniformly smooth, with no external sculpturing. An average of 37 eggs measured gave the following figures: length 0.4 mm. and width 0.29 mm., with a maximum length of 0.5 mm. and a maximum width of 0.33 mm. Measurements of eggs obtained in different humidities have not shown any variations in size, and even those in 100 per cent. R.H. have not shown any increase or swelling in size as a result of any intake of moisture.

Egg cavity.—The eggs, in the majority of cases, are buried in the bast fibres of the bark and in some cases with slight depressions into wood. The presence of the eggs in the stem can be detected easily by an external scar-like mark. They are invariably laid a little obliquely beneath the scar, though cases where they are laid immediately beneath the scar are not uncommon. The egg chamber is usually wider inside than at its opening to the exterior. The scar when fresh is greenish brown and glistening, but after one or two days this lustre is lost, and it turns dark brown in the form of a crust. The glueing is generally flush with the stem, but cases where it is below the stem surface or above it are also met with.

Location of the egg.—The eggs are generally deposited in the region of the nodes, which is tender, soft and succulent. In the case of some of the ovipositional trials on entire plants conducted previously by the junior author, it was found that out of 78 cases of egg-laying, 37 were at the nodes, 39 in various regions other than the nodes, and in two cases, curiously enough, thrust inside the petiole. It was also seen that in the case of Karunganni plants (country cotton), the eggs were invariably laid in the nodes. In the present series of trials, stalks of about an inch in length were supplied for oviposition. The adults usually laid at the cut end or in its vicinity, where the resistance is at the minimum.

Process of oviposition.—Prior to oviposition, the female actively runs about the stem exploring the nodes or other soft parts. On selecting a suitable spot she thrusts her snout into the bark and gnaws into it. The time taken to scoop out the chamber varies a good deal, ranging from 5 to 52 minutes, averaging 15.3 minutes for 97 cases. After completing the cavity, the adult turns round and inserts the tip of the abdomen into the cell. The egg is then deposited in the chamber and the process of sealing and cementing the cavity is effected by repeated up and down and lateral movements of the abdomen. The material used in the operation is a mixture of a gummy exudation and green excreta, producing the characteristic scar, which soon hardens, forming a kind of lid that in the majority of cases is flush with the surface. No gall is developed in this case. The time taken in inserting the egg and cementing the opening averaged 2.4 minutes, the maximum being 4 minutes and the minimum 2 minutes.

In some egg-laying trials conducted by the junior author it was observed that the largest number of eggs was laid between 10 a.m. and 2 p.m., i.e. during the sunniest and hottest part of the day.

Effect of humidity on the preoviposition period in a constant temperature of 93°F.—The data on preoviposition are important as indicating the time taken for the maturation of the gonads, which varies under different climatic conditions. The pre-oviposition period in this weevil, strictly speaking, includes a period spent by the fully formed adult in the stem before its actual emergence. It has been noticed in individual rearing that the fully developed adult emerges from the pupa a few days prior to its exit from the stem, one to three days being spent inside the stem (averaging about two days) before it bites a circular exit hole. But the figures below are calculated from the data of actual emergence, i.e. excluding the time spent in the stalks.

The preoviposition period of adults without food varied from 0.3 days to 1.12 days in different humidities at 93 F., and showed little difference when they were fed on raisin; whereas in 60 per cent. R.H. oviposition took place without any delay, thus proving that, provided congenial conditions exist, there is no need for a preoviposition period. It also shows that the gonads are fully developed and ripe at the time of emergence, and that the adults require only mating to induce oviposition.

5. Influence of varying Humidities on Oviposition under Constant Temperatures.

Freshly emerged females and males were confined in cages with food (a single raisin) or without. A small bit of fresh cotton stalk about an inch in length was introduced in each case as a vehicle for oviposition. The stalk was removed every day and a fresh one supplied in a fresh cage with appropriate moisture conditions. These were placed in incubators regulated to give the required temperatures. The same weevils were used until death supervened. The stalk was carefully dissected under the binocular microscope for eggs, which were counted and recorded along with the number of punctures. The results are presented below.

1. At 122°F. and varying Humidities.

In all, 83 adults were under observation in the different humidities, namely 0 per cent., 20 per cent., 40 per cent., 60 per cent., 80 per cent. and 100 per cent. They were fed with raisin. The trials showed that adults in this high temperature are found to have reached nearly the upper thermal death-point and therefore survive only for a few hours. There was no egg-laying.

2. At 113°F. and varying Humidities.

Oviposition with food.—The weevils seemed to be much distressed in this high temperature and only a negligible number of eggs were laid, the average percentage varying from 0.2 to 0.7 per cent. These occurred only in the higher humidities, none in the lower (0 per cent. and 20 per cent. R.H.). These eggs were without exception infertile. This temperature probably marks the upper limit for oviposition response.

3. At 106°F. and varying Humidities.

Oviposition with food.—The females in this temperature were obviously uneasy. The temperature appears to be far beyond the vital range. The egg capacity was greatly reduced to 1.0 in 100 per cent. R.H., 2.0 in 60 per cent. R.H., 3.5 in 80 per cent. R.H., and 4.5 in 40 per cent., 20 per cent. and 0 per cent. R.H. The eggs were not normal and collapsed, showing that they were infertile.

4. At 100°F. and varying Humidities.

Without food.—On examining the data for these experiments it is found that the humidity requirements increase with the rise in temperature as indicated by a few trials. The average figure of 11.0 eggs per female was the maximum, which was reached in a saturated atmosphere; 60 per cent. R.H. ranked next with 10.0 eggs. The figures obtained for other humidities show some irregularity, which admits of no easy interpretation. The minimum of 6 eggs was obtained in 40 per cent. R.H.; and 7.0, 7.5 and 8.7, in 80 per cent. R.H., 0 per cent. R.H. and 20 per cent. R.H., respectively, are erratic and not comparable. It is apparent that an extremely dry atmosphere is not very unfavourable for oviposition, probably because the oviposition response is more dependent on the moisture available in the stalk than on the atmospheric humidity.

With food.—A maximum of 25.3 eggs was obtained in 60 per cent. R.H. and a minimum of 10 eggs in 40 per cent. An average of 21 eggs occurred even in 0 per cent. R.H., but 100 per cent. R.H. showed a distinct fall to 15.1 per female. The data obtained are irregular, and the behaviour of the adults was highly erratic.

because the temperature range exceeded the vital optimum, as shown by the fact that eggs were not viable in this temperature. The rate of oviposition was greater than in lower temperatures such as 93° and 91°F.

The maximum duration of egg-laying was 7.3 days in a dry atmosphere of 0 per cent. R.H., and 6.5 days in 40 per cent. R.H. In 100 per cent. R.H. a minimum of 3.6 days was noticed. The duration is reversed in this case because by the introduction of a raisin with a high water content the higher humidities were rendered unfavourable owing to excess of moisture; whereas in lower humidities the adults are able to regulate the required humidity by absorbing moisture through feeding on the raisin. This observation is in agreement with that of Buxton (1937). The rate of oviposition was highest in 100°F., and a maximum of 5 per day was reached in 60 per cent. R.H.

5. At 93°F. and varying Humidities.

Without food.—Oviposition takes place in all humidities. The maximum oviposition was 8.5 eggs per female, obtained in 60 per cent. R.H.; 80 per cent. R.H. came next with 7.2 eggs; 100 per cent. humidity showed only 6.1 eggs, and 40 per cent. 6.2 eggs; 0 per cent. and 20 per cent. R.H. were comparatively unfavourable and showed only 4.5 and 5.6 eggs per female, respectively.

With food.—A maximum of 29.2 eggs per female was obtained in 60 per cent. R.H.; about 28.2 eggs were laid in 80 per cent. R.H. and 26.2 eggs in 40 per cent. R.H. One hundred per cent. R.H. seems to be definitely unfavourable with a food like raisin having a high water content, as it yielded only 9.8 eggs. The dry atmosphere of 0 per cent. R.H. and 20 per cent. R.H. showed an increase from 4.5 and 5.6 in unfed to 17.3 and 22.0, respectively, when a raisin was introduced. These figures seem apparently to indicate that a dry atmosphere is not unsuitable for oviposition. At a suitable temperature, oviposition takes place in all humidities, although an increase is noted in higher humidities. In dry atmospheres of 0 per cent., 20 per cent. or 40 per cent. R.H. oviposition occurs because moisture always exists in the stem and bark, and all that seems essential is moisture on the plant surface. It shows that irrigated crops afford suitable conditions for oviposition. In cages the condition has been improved by the introduction of a highly moist food. No doubt the dry atmosphere of 0 per cent. and 20 per cent. R.H. generally drains off water from the weevil, but the provision of moist food enables the insect to recuperate the loss by feeding and thereby maintain a favourable equilibrium of the water content.

Duration of egg-laying period without food.—A maximum duration of 3.8 days was obtained in 60 per cent. R.H. and a minimum of 2 days in 0 per cent. R.H. The duration in 80 per cent. R.H. was the next longest; and the others, namely 20 per cent., 40 per cent. and 100 per cent. R.H., were more or less equal. The duration is a factor directly varying with longevity. The data show that the optimum for longevity is the same as for duration of egg-laying.

Egg capacity without food.—The maximum egg capacity of 8.5 per female was attained in 60 per cent. R.H., where the egg-laying period also is the longest; and deviations in egg capacity vary directly as the duration of the egg-laying period.

Rate of oviposition without food.—There is very little variation in regard to the rate of egg-laying, as the figures range only from 2.1 to 2.6 eggs per day per adult.

Duration of egg-laying period with food.—This is shortest in 100 per cent. R.H., because of excess of moisture due to the presence of a raisin. The conditions in 0 per cent., 20 per cent., and 40 per cent. R.H. were improved by introducing the raisin, and these humidities seem to be less unfavourable than 100 per cent. R.H. The maximum duration was in 80 per cent. and 60 per cent. R.H., with 16.3 and 15.8 days respectively; 60 per cent. R.H. is the optimum, in that it produces maximum egg capacity with the shortest duration.

Rate of oviposition with food.—This is quicker, *i.e.* 2.0 and 2.1, in unfavourable humidities like 0 per cent. and 100 per cent. R.H., respectively; the rate from 20 per cent. to 80 per cent. R.H. being very nearly the same, varying from 1.7 to 1.9.

6. *At 91°F. Mean Temperature and 73 per cent. Mean Humidity.*

With food.—The egg capacity was highest under these conditions, showing a record number of 121 eggs. Previous investigations have not recorded a capacity beyond 30 eggs. The average capacity of 45 individuals is about 46 eggs each, but this fails to give a correct idea of the capacity. Nearly 50 per cent. of the adults laid more than 50 eggs each, and nearly 9 per cent. laid over 80 eggs each. Only two adults failed to oviposit.

The duration of the egg-laying period averaged 38.5 days with a maximum of 78 days, but the rate of oviposition was reduced to 1.4 per female per day. The longevity of the females averaged 50.5 days, with a maximum longevity between 70 and 90 days, which very nearly equals the record figure obtained by mated females with food in 93°F. and 60 per cent. R.H., where a female attained 98 days and an unmated male 96 days.

7. *General Effect of Temperature on Oviposition.*

From the experiments so far conducted within a range of 91°–122°F. the optimum temperature-humidity combination for both productivity and longevity appears to be somewhere near 91°F. and 73 per cent. R.H. Trials in lower temperatures have not been attempted. Egg capacity in 93°F. is seen to be distinctly reduced, and still more so in 100°F.; but fertile eggs are not viable at this latter temperature. A temperature of 106°F. marks the upper limit for laying fertile eggs, and 113°F. the limit for oviposition, whether fertile or infertile, while 122°F. is the lethal limit for adults.

8. *Failure of Oviposition at 93°F. Constant Temperature and varying Humidities.*

Humidity has considerable influence in retarding the urge for oviposition, the retardation being at its maximum in a dry atmosphere, *i.e.* 0 per cent. R.H., which prevented oviposition in 64.3 per cent. of adults. Even a saturated atmosphere has a deleterious effect on oviposition, 46.5 per cent. of adults having failed to oviposit. The minimum percentage of adults which failed to oviposit was 22.4 per cent. in 60 per cent. R.H.; this humidity may, therefore, be considered as the optimum in this temperature, which is supported by egg capacity data also. In 80 per cent. R.H. 30.5 per cent. of adults failed to oviposit, the percentages in 20 per cent. and 40 per cent. R.H. being 41.3 per cent. and 43.3 per cent. respectively.

9. *Influence of Temperature on Hatching under different Humidities.*

At a constant temperature of 93°F.—0 per cent. R.H.: Beginning with a dry atmosphere, about 50 healthy eggs were kept under observation in this humidity and examined at intervals varying from 2 to 9 days. On the second day the eggs collapsed, and a few days later they were completely dried up and crumbled to powder.

20 per cent. R.H.: A batch of 66 eggs was kept under observation in this humidity, and within 2 to 3 days they shrivelled, ultimately drying up without hatching.

40 per cent. R.H.: In 40 per cent. R.H. 55 eggs were under observation and shrivelling was noticeable even on the second day. Eventually they all dried up, except two, which were more or less intact, but even these failed to show any signs of an embryo.

60 per cent. R.H.: As many as 91 eggs were experimented with in this humidity, and remained healthy and intact for four days. From the 5th day onwards nearly 65 collapsed, and there was an apparent hatching in only 15 eggs. Among these there were only four cases in which the larvae had emerged from the egg-shell. In

the remaining eleven cases the larvae were found dead after partial hatching and in a few cases after complete emergence ; in these cases the embryos were found normally developed inside the chorion.

80 per cent. R.H. : As many as 121 eggs were experimented with in this humidity. For four days after laying no case of hatching was observed, the eggs being all healthy. On the 5th day hatching commenced and by the end of the 6th day the great majority of eggs hatched with the larvae healthy, apart from a few collapsed eggs and a few dead larvae. From the 7th day onwards the larvae survived in diminishing numbers up to a period of 22 days, but the great majority did not survive beyond the 11th day. From the 11th day onwards out of a total of 61 larvae nearly 58 were found dead by the 22nd day. In all these cases the mortality of the larvae was not brought about by fungus but by shrivelling.

100 per cent. R.H. : As large a number as 412 eggs was under observation in this humidity. Till the 4th day, eggs were intact and no hatching occurred. On the 5th day out of 56 eggs examined, 29 were found hatched, with 26 unhatched but healthy and one collapsed. On the 6th day, out of 54 eggs examined, all were found hatched and 49 larvae alive and active, with 5 larvae killed by fungus. The larvae were kept in the same stalk and same humidity and developed healthily up to 33 days, by which time they were nearly medium-sized grubs ; mortality in this humidity was mainly brought about by fungus, the stalk getting mouldy. It has been noticed that by occasional changes of stalk the grubs could be reared to adults in this humidity.

To summarise, it can be seen that a dry atmosphere is inimical to hatching of eggs. Such low humidities as 0 per cent., 20 per cent. and 40 per cent. do not allow of embryonic development and all eggs collapse in 2 to 3 days. In 60 per cent. R.H. the embryo has normal development and partial hatching in a proportion of cases with the embryo unable to extricate itself from the chorion and therefore dying *in situ*. In 80 per cent. R.H. there is partial hatching of the eggs, but the larvae live for varying periods up to 8 days with a few exceptions. Mortality is never brought about by fungus. A saturated atmosphere seems to be the optimum under this temperature for the hatching of eggs and early larval development. For every favourable temperature there seems to be a distinct humidity range for successful hatching of eggs.

At a mean temperature of 91°F. and 73 per cent. R.H.—As many as 77 eggs were under observation in this combination. There is slight variation in the incubation period according to temperature, it being reduced as temperature rises. In 91°F. the incubation period is never less than 6 days whereas in 93°F. the period is shortened to 5 days, there being 50 per cent. hatching on the 5th day itself and the remainder hatching on the 6th day.

10. Viability.

In a temperature of 100°F. it has been noted that there is a reduction in the total production of eggs, as also in the egg laying period and longevity. The temperature therefore may be considered unsuitable, being rather high for the weevil's activities. With a view to test the effect of this temperature on eggs, 93 were kept in 100 per cent. R.H. It has been observed that even at lower temperatures perfect hatching occurs only in 100 per cent. R.H. In this case none of the eggs hatched, as they began to shrivel and collapse even from the 2nd day ; some eggs appeared normal and intact but with no indication of the presence of the embryo within, in other cases the egg-cavity in the stem was found blackened with the egg shrivelled up in the centre. In a few rare cases a developed embryo was noticed inside the chorion, but there was absolutely no case of hatching in this temperature.

To test whether these latter eggs were fertile, they were transferred to a lower temperature in the laboratory, namely a mean of 91°F. in the same humidity. Out of 68 such trials, there were 52 cases of perfect and normal hatching. In order to

test whether eggs laid in favourable temperatures would react in the same way when carried to 100°F., a batch of 63 eggs laid at a laboratory mean temperature of 91°F. and 73 per cent. humidity were transferred to 100°F. In the majority of cases the embryos were apparently developed inside the chorion, but died without hatching. In about four cases, the embryos developed and had broken the chorion, thrusting out the head and mandibles, but were dead *in situ*. In the controls in laboratory temperatures, nearly 100 per cent. hatched. These observations go to show that in 100°F. there is development of the gonads and fertility of eggs, but no hatching. This temperature, therefore, in the absence of experiments in slightly lower temperatures, may be considered to be in the immediate neighbourhood of the upper thermal limit for hatching.

6. Influence of Humidity on Immature Stages at 93°F.

From the data obtained on incubation, it was evident that the newly hatched grubs are extremely sensitive to desiccation. The data recorded under this head clearly show that eggs fail to hatch in lower humidities, namely, 0 per cent., 20 per cent., 40 per cent. and 60 per cent. R.H. There is only partial hatching, with the embryos drying before emergence from the egg-shell, 80 per cent. R.H. shows complete hatching, but the grubs thrive only for the short period of a week; 100 per cent. R.H. has been noted to be the humidity in which the newly hatched grubs thrive best and live longest, barring the handicap of fungus attack. In order to verify these observations, a series of experiments on early grubs introduced into stems and kept in different humidities was made. The results were in conformity with the previous observations; lower humidities increased their mortality and retarded their growth.

Medium-sized grubs.—In all 28 grubs of this size were under observation in different humidities. These larvae, unlike the smaller ones, withstand and develop to some extent even in extremely low humidities, but after tunnelling the stalk for some distance get dried up in such humidities as 0 per cent., 20 per cent. and 40 per cent. In 80 per cent. R.H. and higher humidities, trouble arises from fungus, which prevents their development to a great extent, but even in 100 per cent. R.H. some medium sized larvae were reared to adults. The optimum for medium-sized grubs seems to be near 60 per cent. R.H.

Mature grubs.—There were 31 trials of this stage in different humidities. In 0 per cent. R.H. the grubs were found to grow; in two cases adults developed, and in another the grub became a prepupa and died, and in still another the grub had developed into a pupa. In 20 per cent. R.H. out of 14 cases, four adults developed, three of which were alive and one dead, and two grew to the stage of pupae and died. In 40 per cent. R.H. 19 trials were made, yielding four adults (three of them alive), two prepupae and one pupa, which, however, was dead. In 60 per cent. R.H. 17 larvae were used, two of which developed into living adults; in five cases they had advanced to the pupal stage and died, and there was one dead. In 80 per cent. R.H. 16 cases were under observation; in two cases adults were obtained, of which one was alive, five had developed to pupae, with three alive and two killed by fungus, which also killed all the others. In 100 per cent. R.H. 16 larvae were tried, and none developed into an adult; three became pupae, but were killed by fungus, as were the rest of the larvae.

7. Effect of Humidity on Prepupae and Pupae at 100 F. constant Temperature.

Prepupae.—The prepupae all died in humidities of 40 per cent. and over owing to heavy fungus growth. They appear to pupate more rapidly in medium and lower humidities; high humidities are distinctly unfavourable.

Pupae.—In 0 per cent. R.H., out of 19 pupae, almost all reached the adult stage in an ill-developed condition and were found dead. In 20 per cent. R.H., out of

four pupae, two dried up and two produced live adults. In 40 per cent. R.H., out of three pupae, two emerged as adults alive, and the third was ill-developed and died. In 60 per cent. R.H., out of 6 pupae, one developed into a living adult and the rest were attacked by fungus and killed. In 80 per cent. and 100 per cent. R.H., ten pupae were all killed by heavy fungus growth.

8. Development and Life-cycle.

The life-cycle of the insect has been previously investigated and found approximately to occupy 57 days (Ramakrishna, 1918) and a little over two months (Ballard, 1922), but it is only in a few cases that the cycle has been carried through to the adult stage. To effect this, repeated changing of the cotton stems is required, as the life-cycle is fairly long. Since the different stages require varying conditions of humidity, repeated transfers from one humidity to another facilitate development. The duration of these stages has been more easily worked out under controlled conditions, and sufficient data on this aspect have been gathered; the difficulty of rearing this weevil arises mainly during the active larval stage. By repeated changing of the stems successful emergence has been obtained in a few cases. After the eggs had hatched and the early grubs developed to some extent in higher humidities, they were transferred to lower humidities, with the result that their development was seen to be accelerated. For instance, when mature larvae obtained in 100 per cent. R.H. were continued in the same humidity at 93°F., they showed a life-cycle of 66 days, and this period was fairly uniform in three successive cases; whereas larvae in a similar advanced stage when transferred to 60 per cent. R.H. gave a shorter life-cycle of 52 days, showing a quickening of development in a lower humidity.

9. Discussion.

Pempherulus and its early Association with Cambodia Cotton.

The spread of this weevil was associated with Cambodia cotton by earlier writers, and this was attributed to the insect's specificity to this variety. But later observations show that the attraction of the pest to this cotton is due rather to the conditions of optimum temperature and moisture, particularly the latter, under which this cotton is cultivated. In other words, the physical requirements of an irrigated crop and those of the weevil are nearly identical. Naturally, therefore, when Cambodia cultivation extended in South India, the insect was also more widely disseminated.

Incidence in Dry Country Cottons (indigenous Varieties such as Uppam and Karungani).

These were originally recorded as free from the attentions of the pest. Later, infestations were noted on these crops in tracts situated near garden lands. Still later, heavy infestations were found on them when grown under irrigated conditions for experimental purposes. But the dry cottons situated in the dry blacksoil stretches remote from garden lands where high temperatures prevail ranging from 100°F. to 109°F. were seen to be absolutely free. The belt of country cottons grown in the immediate vicinity of garden lands generally permitted the development of the insect only in the first generation, that is in the early stages of the crop. It has also been noted that the insect is unable to breed in the crop any further as the grubs get parched up in the stems. These observations may now be interpreted with the help of the laboratory data. Moisture, either available in nature through precipitation or supplied by irrigation, seems to be the governing factor for incidence of the pest. It is not, therefore, so much a question of varieties that influence incidence as that the conditions favourable for the culture of Cambodia cotton are also conducive to the breeding of the weevil.

Distribution.

In the southern districts of this province the pest enjoys a wide distribution, but is absent in certain tracts. In the hot dry plains of Ramnad and Tinnevely the infestation is not very heavy. In such tracts the country cottons bordering the irrigated area alone show infestation; and such of the cottons lying away from these irrigated cottons, in the centre of the blacksoil stretches, are completely free from the pest. The absence of the insect may now be partly explained as due to such factors as high temperature and low humidity and little or no precipitation. The eggs do not hatch and the grubs fail to develop in situations like Koilapatti, where the temperature goes to 100°F. and beyond.

The weevil occurs in Behar, Guzerat and United Provinces (Dehra Dun), either in garden plants like bhindi or in alternative food-plants found growing in shady or moist situations, and this too in small numbers. These tracts are nearly devoid of any irrigated cottons. Conditions of temperature and humidity are characterised by wide extremes in summer and winter.

The conditions obtaining at Coimbatore and round about, as also in Malabar, seem to be the optimum for the successful multiplication of the insect. The climate is equable; conditions of temperature and humidity do not run to extremes. There is plenty of irrigated cotton in the district which forms a good breeding ground for the pest. In Malabar also, though cotton cultivation is practically absent, the pest is in abundance; there is heavy rainfall and the general climate is very moist; there are alternative food-plants in moist situations and near forest regions which afford excellent conditions for its heavy breeding.

Seasonal Variations.

It may be noted in this connection that the initial incidence on the seasonal crop is low as the immigrants are few; heavy populations are built up gradually, and there is decline in population after about the second generation. Seasonal studies of incidence and its fluctuation when correlated with climatic data for a series of years may afford clues for its control.

Differential Requirements of various Stages of the Weevil.

It may be seen from the experimental data that the temperature-moisture complex exercises a profound influence on the insect as a whole, on its survival, reproduction, development and multiplication, and to these factors may also be traced the most important causes of their mortality and elimination. Field observations have shown that an equable or moderate climate is the best for its general multiplication. In general terms, excessive heat or dryness seems to be inimical to its existence. The influence of excessive cold remains to be investigated. Within the area of its distribution, its occurrence is confined to moist humid localities or situations. Laboratory data so far obtained serve to elucidate further the full significance of these observations.

In 93°F. the egg-layings have been at the maximum in 60 per cent. R.H. Although oviposition is tolerated in all humidities, proper incubation needs a high degree of moisture. Drier atmospheres, such as 0 per cent., 20 per cent. and 40 per cent. R.H., are unsuitable for development of the embryo, since the eggs shrivel and collapse. In 60 per cent. R.H. there is embryonic development with no hatching or only partial hatching, with the young larvae often collapsing *in situ*. In 80 per cent. R.H. there is complete hatching of the eggs, but the larvae do not seem to thrive long. It is in 100 per cent. R.H. that perfect hatching occurs and the larvae thrive and complete their development. In a higher temperature, the eggs fail to hatch in 100 F. even in as high a humidity as 100 per cent. R.H. The hatching period, however, is not much affected by variations in humidity or temperature because the egg is situated inside the plant tissue. The humidity requirements of the older larvae,

prepupae and pupae, vary inversely with the rise in temperature. In 60 per cent., 80 per cent. and 100 per cent. R.H. all such advanced stages die owing to fungus, even with repeated changes of stalks. Prepupae and pupae develop to adults successfully in 0 per cent., 20 per cent., and 40 per cent. R.H. in 93°F.; whereas the same stages get parched up in the same humidities in a higher temperature of 100°F., or occasionally grow to ill-developed adults.

The adults live the longest, with a maximum life of three months, in 60 per cent. R.H. and a temperature of 93°F.; whereas in 100°F. the longevity is reduced to about a month with a supply of food. In regard to development and total life-cycle, it has been seen that it occupies a period of 66 days in 100 per cent. R.H. at 93°F.; whereas the period is shortened to 52 days in the same temperature when transferred to a humidity of 60 per cent.

So far as our present range of experiments indicate, maximum egg-production, namely 121 eggs per female, has been obtained in a mean temperature of 91°F. with a mean humidity of 73 per cent. The egg-laying period also is lengthened to 78 days. An average of 50 eggs is recorded per female. In these conditions, females mated and isolated in the beginning have laid fertilised eggs for a period of 65 days after emergence. The eggs laid at the end of this long period were fertile.

These laboratory data demonstrate that the stages which are most highly sensitive to desiccation are the eggs and the early grubs, and to a certain extent the medium-sized grubs also; these stages demand high humidities, even up to saturation point.

Despite these findings the authors are unable to specify the exact limits of the vital zone or its absolute optimum combination of temperature and humidity, as the studies are still incomplete, and have been made only in a few higher temperatures. In order to enable them to define the limits these experiments have to be extended to various other ranges of temperatures and humidity, which the writers propose to pursue.

10. Summary.

1. This preliminary paper is an attempt to elucidate the intricate relationship existing between *Pempherulus* and its physical environments.

2. A convenient technique adapted for evaluating the effects of major climatic factors, such as humidity and temperature, in the case of *Pempherulus* has been described.

3. Its occurrence only in the irrigated crops is attributable to its high requirements of moisture.

4. A lengthy exposure is necessary to kill the adults in temperatures of 113° and 106°F. An exposure of 6 hours seems to kill them in 122°F. and 48 hours in 113°F. The upper thermal death-point lies roughly near 122°F.

5. The upper vital temperature limit is seen to lie near 100°F. It is indifferent to variation in humidity above 100°F.

6. Adult life is prolonged as the temperature is lowered (within a range descending from 122°F. to 91°F.) from a longevity of 6 hours to a period of 98 days, respectively. A maximum longevity of over three months is obtained with oviposition, in a mean humidity of 73 per cent. and 91°F. A high degree of humidity (such as 60 per cent. and 80 per cent.) is necessary in normal temperatures (such as 93°F.) for obtaining maximum adult longevity.

7. Within vital limits the optimum humidity requirements vary directly with the temperature. In 93°F. the optimum lies between 60 per cent. and 80 per cent. R.H. and in 100°F. between 80 per cent. and 100 per cent. R.H.

8. The mated and unmated adults differ in longevity. The maximum in unmated males was as high as 98 days, whereas in mated males it was as low as 58 days in 60 per cent. R.H. Similarly the unmated fed female lived as long as three months, whereas for the mated fed female, not allowed to oviposit, the time was 54 days—all in 93°F.

9. Evidence is presented to show that the species is probably unable to develop, reproduce and multiply in temperatures above 100°F. (except when the microclimate is exceptionally favourable). The upper limit for oviposition is about 113°F.

10. Egg-laying capacity decreases with a rise in temperature from a maximum average of 46 eggs in 91°F., 29.2 in 93°F., 25.3 in 100°F., 4.5 in 106°F., 0.7 in 113°F., to nil in 122°F., the eggs in the case of 106°F. and 113°F. being collapsed.

11. The upper limit for hatching of the eggs is indicated as distinctly below 100°F., while the limit of embryonic development lies near about 100°F.

12. A wide range of tolerance is exhibited in regard to humidities for oviposition, as the ovipositional variations shown in the different humidities do not admit of any interpretation.

13. Humidity requirements within vital limits for oviposition vary directly with rise in temperature; the optimum in 100°F. lies between 80 per cent. and 100 per cent. R.H.; in 93°F. between 60 per cent. and 80 per cent. R.H.; and in 91°F. it appears to be about 73 per cent. R.H.

14. The requirements of eggs and first stage larvae for hatching and survival are defined. These are 60 per cent. humidity for partial hatching; 80 per cent. for complete hatching; and 100 per cent. R.H. the best for hatching and survival of the larvae. The incubation period is not much affected by humidity variations in normal temperatures, the range being only about a day.

15. Eggs and early stage larvae are very sensitive to desiccation and require a high degree of moisture. The greatest mortality occurs in these stages.

16. Whereas prepupae and pupae can withstand and develop in even such low humidities as 0 per cent., 20 per cent. and 40 per cent., a humidity of 100 per cent. is inimical for the older stages on account of fungus growth.

17. The velocity of development for mature larvae, prepupae and pupae, varied inversely with the rise in relative humidity, as can be seen from life-cycle periods of 66 days in 100 per cent. R.H. and 52 days in 60 per cent. R.H.

18. The need for further investigation on these lines in varying combinations of humidities and temperatures, particularly lower than 91°F., is demonstrated.

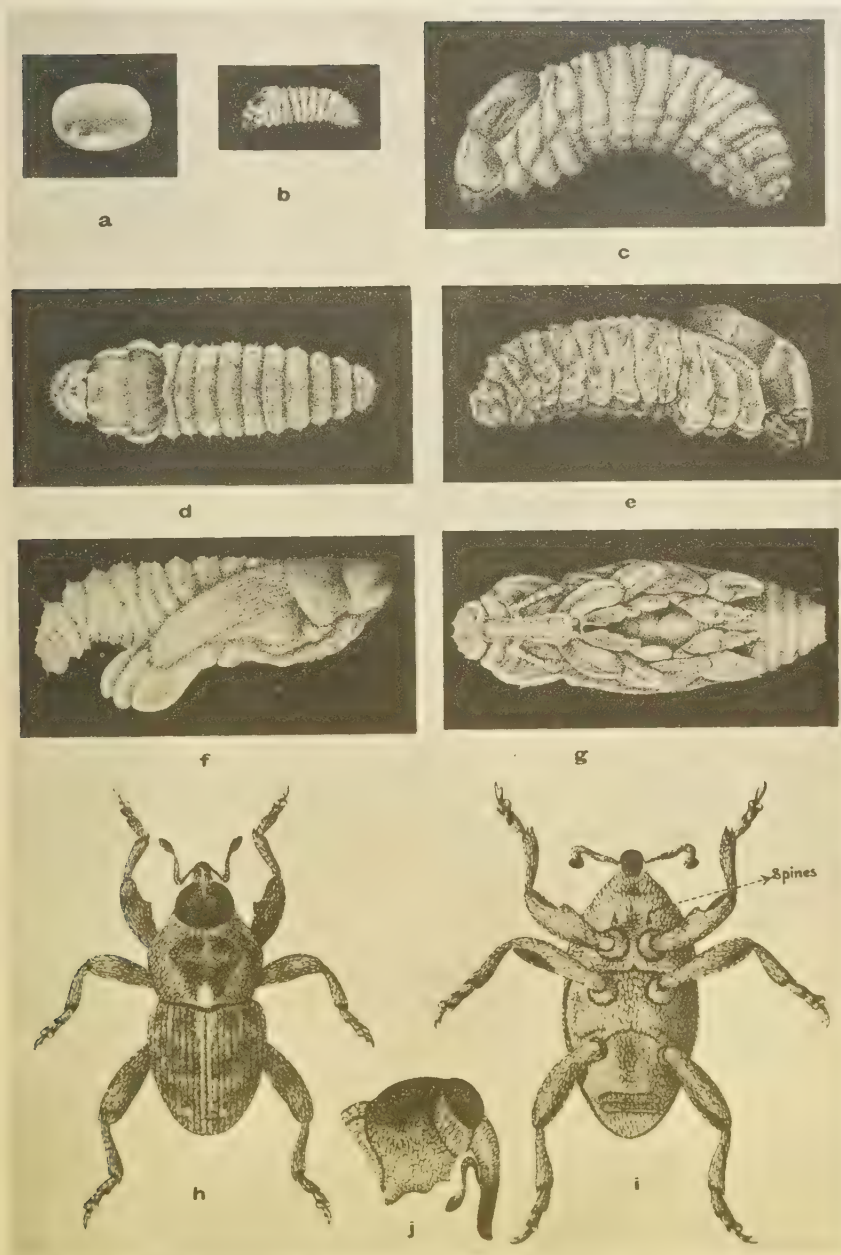
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Pempherulus affinis, Fst.: a, egg; b, 1st instar larva; c, full-grown larva; d, prepupa (dorsal view); e, prepupa (side view); f, pupa (early stage) side view; g, pupa (advanced stage) ventral view; h, adult ♀ (dorsal view); i, adult ♂ (ventral view); j, head (side view).

CAPSID PESTS OF CACAO IN NIGERIA.

By F. D. GOLDING, M.A., F.R.E.S.

Introduction.

The Capsid bugs, *Sahlbergella singularis*, Hagl., *S. theobroma*, Dist., and *Helopeltis bergrothi*, Reut., have been recognised as pests of cacao in the Gold Coast for more than 30 years^{7,8}. Whilst there has never been any divergence of opinion as to the major status of *Sahlbergella* as pests of cacao, this does not appear to be true of *Helopeltis*. Patterson (see various reports of the Gold Coast Department of Agriculture,^{17, 18, 19, 20}) considered *Helopeltis* to be a major pest and indicated that damage to shoots, as well as to pods, is frequent; whereas Cotterell⁹ describes *H. bergrothi* as a minor pest of cacao and states that "damage to herbaceous shoots is of very rare occurrence." In 1939 Cotterell⁶ reported that he had found another Capsid (? *Bryocaropsis* sp.) to be comparatively widespread on cacao around Tafo.

In 1914, Mayné & Vermoesen¹³ gave a detailed account of the bionomics of *S. singularis* on cacao in the Belgian Congo; these authors also mentioned *Helopeltis* as attacking pods and shoots, though these bugs were not numerous.

S. singularis was first described by Haglund in 1895 and, seven years later, was recorded by Warburg¹⁵ as a pest of cacao in the former German colony of Kamerun.

The first record of *Sahlbergella* in Nigeria was the discovery by Lamborn¹⁰, in 1914, of *theobroma*, which "occurred sparingly in the Onipe district" (about 16 miles south of Ibadan). Later in the year²¹, Farquharson observed a nearly allied species (presumably *singularis*) on cacao farms in the Eastern Division; the bugs were said to be a serious menace to the crop¹⁰. In 1915²², Farquharson, during tours through Egbaland (Abeokuta Province) and the Ibadan and Ijebu-Ode districts, observed numerous instances of injury caused to cacao trees by *S. theobroma*; numerous nymphs were found on the pods, but none on the vegetative parts of the trees. The writer believes that there is no doubt that most, if not all, of the bugs seen by Farquharson were *singularis*. His reason for this belief is that during his first twelve years in Nigeria (1922-1933) he did not see a single specimen of *theobroma* and, as described below, has seen but few individuals of that species in the succeeding years. *H. bergrothi* was first seen on cacao in August 1939, during the writer's first visit to the Ondo area.

Sahlbergella singularis*, Hagl.*(a) In the Ibadan district.**

In the Ibadan district, in which the headquarters of the Nigerian Agricultural Department are situated, *singularis* is common on pods during the latter part of the rainy season (August to October); but except on occasional farms, the damage to shoots is negligible. During early May 1939, a thorough search was made on cacao on Moor Plantation and on native farms in the vicinity of Ibadan; only one small nymph of *singularis* was found. In late July, one colony of nymphs was found on a tree on Moor Plantation and, by October, *singularis* had become fairly numerous both on the Plantation and on a number of native farms in the vicinity. By early February 1940, the bugs had decreased to negligible numbers; no adults could be found and there were small groups of nymphs, of different instars, under the few pods which had not then been harvested. After the harvest had been completed, in mid-February, *Sahlbergella* could not be found. There was no evidence of parasitism, and it seems probable that the climatic conditions which usually prevail between late

December and early February have a controlling effect upon *Sahlbergella* in the Ibadan district. In this period there is usually a spell of "harmattan" weather, characterised by low night temperatures and a considerable reduction in atmospheric humidity during the late morning and afternoon.

During the 1939-40 season, serious damage was done to only one farm. This was a small isolated area, of about 400 sq. yards, on which were growing 71 trees. During October, considerable damage was done to the shoots on most of these trees. A survey was carried out on 3rd November, and it was found that there were 81 pods on 19 of the trees and none on the remaining 52; *Sahlbergella* lesions were present on 78 out of the 81 pods. Five adults and 21 nymphs of *singularis* were either on shoots or in fissures of branches or stems and 21 nymphs of that species were on or under pods. There were outcrops of rock in several parts of the farm, and examination of the soil showed that at a depth of from one to two feet there were many stones. As might be expected, the trees were unhealthy and, at the time of writing (June 1940), about 12 of them appear to be dead. The mean annual rainfall at Ibadan is 49 inches (1905-39); during the last four years the rainfall has been from 5 to 10 inches below the average.

(b) *At Owena.*

This village lies about half-way between Akure and Ondo and, according to figures obtained by the Botanical Section, has a mean annual rainfall of about 63 inches. It is a forest area and during the last 17 years has been extensively cleared for cacao-planting; there is a Government Farm in a forest reserve, near the village, containing cacao planted in 1935 and citrus, the oldest trees of which were planted in the previous year.

Considerable areas in the native cacao farms were reported to have been attacked by *Sahlbergella*, and the writer visited Owena in August 1939. The damaged trees occurred in patches of varying sizes, sometimes as much as 5 to 10 acres in extent; dead leaves were still attached to these trees, which were putting out new shoots. Only 6 adults and 66 nymphs of *singularis* were seen in the course of a nine days visit, during which all the cacao farms within a radius of about four miles of the village were examined. Frequently in the middle of a patch of damaged trees there were small treeless areas, due sometimes to the presence of an outcrop of rock. In other instances, it seemed probable that the absence of trees was due to the activities of termites which had spread from fallen forest trees; in others, to patches of poor soil.

The comparative scarcity of *singularis* in August makes it seem probable that at Owena, as at Ibadan, the population falls to negligible proportions at the end of the dry season. It increases rapidly towards the end of the rains, and the bulk of the damage to the vegetative parts of the trees is done during a few weeks (at some time between October and December) when the bugs have attained their maximum numbers and harvesting has reduced the available supply of pods. This point requires confirmation; if it is found to be correct, it is obvious that handpicking during July, when the bugs are not yet numerous and are mainly confined to the pods, would not only be practicable, but also would have an important controlling effect. During next month it is hoped to carry out an experiment on these lines at Owena.

***Sahlbergella theobroma*, Dist.**

(a) *In the Ibadan district.*

In November 1934, Mr. E. H. G. Smith, formerly Senior Botanist, informed the writer that insects were attacking the shoots of young citrus trees on Moor Plantation. Examination showed these pests to be nymphs of *theobroma*—the first ever seen by the writer—and adults were bred out on 13th December. During

October and early November 1935, *theobroma* occurred on young citrus in somewhat larger numbers than in the previous year. One adult was seen in October 1936, and a few nymphs were noticed on young citrus in the autumn of 1939. *Sahlbergella* infestation of young cacao (under five years old) is infrequent at Ibadan and, in the writer's experience, *singularis* is invariably the species concerned.

(b) *At Owena.*

In July 1935, Mr. O. J. Voelcker, Senior Botanist, collected some adult *Sahlbergella* from cacao on the Government Farm at Owena; with one exception, all the specimens were *theobroma*. Handpicking was recommended and has been carried out when required in the ensuing years. The writer examined the Government Farm in August 1939, and found that a number of citrus trees had been planted along one edge of the plot containing 1935-planted cacao. Three adults and two nymphs of *theobroma* were on 1936-planted orange and tangelo trees, and there were typical lesions on a number of older trees. Handpicking was being carried out thoroughly on the cacao, but the citrus provided a continual source of reinfestation. Not a single specimen of *theobroma* could be found on native farms containing young cacao trees.

Helopeltis bergrothi, Reut.

(a) *Taxonomy.*

In 1925, the writer⁹ described some experiments carried out in the previous year which demonstrated the role of *Helopeltis* as a pest of cotton in Southern Nigeria. The bodies and legs of the majority of the adult bugs were orange in colour, but there were a few individuals in which the orange coloration was replaced by a bright red. These Capsids were identified by the Imperial Institute of Entomology as *H. bergrothi*, Reut., and *H. sanguineus*, Popp., respectively. Lean¹¹ found that there were no apparent differences between the life-histories of the two species and that it was impossible to differentiate between their nymphs. In 1934, the writer sent specimens of both species to Mr. H. Hargreaves in Uganda, who informed him that they were merely forms of one species—*bergrothi*; Mr. Hargreaves had apparently bred out series of adults. During the last 12 years, *Helopeltis* has become one of the most important pests of cotton in Southern Nigeria. The writer has not infrequently seen orange males and red females *in copula* in the field.

In the Gold Coast, *bergrothi* is a well-known pest of cacao, whilst the cotton *Helopeltis* of Togoland is *labaumeyi*, Popp. Cotterell¹⁴ recorded *bergrothi* as the cotton pest in 1928; but, in 1935, informed the writer that the species had recently been identified as *labaumeyi*. 87
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In the Belgian Congo, Leroy¹² records *bergrothi* as a pest of cotton. Both he and Cotterell¹³ give coloured illustrations of the adults, eggs and nymphs of *bergrothi*, from cotton in the Congo and from cacao in the Gold Coast, respectively; it seems to the writer abundantly clear that they are distinct species.

When the writer visited Owena in August 1939, he found a species of *Helopeltis* attacking the pods and shoots of cacao, which was new to him and quite dissimilar from the cotton *Helopeltis* of Southern Nigeria. The nymphs were pale green and red in colour and resembled those illustrated by Cotterell¹³, but the thorax and abdomen of the adult were banded in three different colours. The thorax was orange, the fore part of the abdomen was pale green and the hind part bright red. They were subsequently identified by the Imperial Institute of Entomology as *bergrothi*, they are certainly specifically distinct from the cotton *Helopeltis* of Nigeria and the Congo (which the writer believes to be identical), and the adults bear but little resemblance to the cacao *Helopeltis* of the Gold Coast, illustrated by Cotterell.

Sir Guy Marshall has informed the writer that many new species of *Helopeltis* have been made recently and that it is almost impossible to tell whether these are really species or merely colour varieties, unless good series of both sexes are available for examination. It is hoped to obtain bred series of the cotton and cacao *Helopeltis* of Nigeria in the near future. Dried specimens of the latter species rapidly lose their distinctive coloration, a fact which must add considerably to the difficulties of the Museum systematist.

(b) *At Owena.*

During a nine days visit, 18 adults and 51 nymphs were seen. One nymph was found on a young shoot, which bore typical bug lesions, and the remainder were on pods. One adult was seen, soon after dawn, feeding on a shoot and three others were observed resting on shoots which bore fresh lesions. Three adults of *H. westwoodi*, White, were also found on pods. A common plant of the cacao farms, *Solanum verbascifolium*, bore characteristic *Helopeltis* lesions on its leaves and there were brown, cankerous wounds near the terminal buds of many shoots; a number of the very young leaves had been killed. *H. westwoodi* adults were fairly common on this plant and one nymph, probably of that species, was seen on the lower surface of a leaf. In addition, three adults and one nymph of *bergrothi* were found on *Solanum*. The number of *Helopeltis* seen appeared to be insufficient to account for the extensive damage to *Solanum*, and the writer believes that there must have been far greater numbers of these Capsids present in the area shortly before his visit. Reduviid bugs, of various species, were abundant and may have been responsible for the supposed diminution in numbers. One of these Reduviids, *Sphedanolestes cinctipes*, Sign., somewhat closely resembles *Helopeltis* in coloration and has been found to attack the cotton species at Ibadan.

In March 1940, an assistant visited Owena and, during a six days' survey of the various cacao farms, did not see a single specimen of *Helopeltis*. A few *Sahlbergella theobroma* were present on the Government Farm and 7 adults and 37 nymphs (25 on pods) of *singularis* were seen on native farms.

(c) *In other localities.*

In October 1939, *H. bergrothi* adults and nymphs were discovered on cacao at Araromi, 22 miles S.S.E. of Ibadan, and also on some farms from 11 to 13 miles due south of Ibadan. In the latter locality there is a Native Administration farm containing six-year-old cacao trees. *Solanum verbascifolium* is used as a shade plant; it is topped at intervals during the rains until September, when it is left untouched until the end of the dry season (March). There was a heavy infestation of adults and nymphs of the cotton *Helopeltis* on *Solanum* in October, but no individuals of that species could be found on cacao. *H. bergrothi* was present in small numbers on cacao, none was seen on *Solanum*.

At Araromi *H. bergrothi* was more abundant and, on three occasions during November 1939, nymphs were seen feeding on young shoots; the observations were made at 6.45 a.m., 6.55 a.m. and 8.43 p.m. During the daytime several nymphs were observed resting near the extremities of young shoots, which bore evidence of having been attacked.

H. bergrothi has never been found in the Ibadan district.

In some cage experiments, at Ibadan, nymphs of the cotton *Helopeltis* fed readily on cacao pods and also completed their development. An adult, placed in a sleeve over a young shoot, fed and seven days later the terminal portion was found to be dead.

Cage experiments on the Native Administration farm, 13 miles south of Ibadan, showed that when either the adults or nymphs of *H. bergrothi* feed on young shoots the terminal bud is almost invariably destroyed. Van Hall¹⁴ gives an excellent photograph showing *Helopeltis* damage to a cacao twig in the Dutch East Indies.

(d) *The economic importance of Helopeltis on Cacao in Tropical Africa.*

Van Hall¹⁴ states that "the African *Helopeltis bergrothi*, which has been recorded in the Gold Coast Colony, Congo, Southern Nigeria, Uganda, Fernando Po, and San Thomé, is a much less harmful cacao-pest than the African *Sahlbergella* pest or the two *Helopeltis* species already described from Java and Ceylon." It is now known that the cotton *Helopeltis* of Nigeria is not *bergrothi*. Cotterell⁵ has recorded that *bergevinii*, Popp., is the species occurring in Fernando Po and that *sanguineus* is the commonest species in San Thomé; he attributes but little importance to *Helopeltis* spp. in either of those islands or in the Belgian Congo.

The writer believes that *Helopeltis* is probably responsible for more damage to the vegetative parts of cacao in West Africa than is at present realised, and that the bulk of this damage occurs during a restricted period in the rainy season. Cotterell³ states that "*Helopeltis* prefers areas where humidity is low or variable throughout the year" and that "as soon as a hole is made in the canopy of shade, attack at once commences on the pods of the surrounding trees." The writer has observed *Helopeltis* to be numerous in patches of cacao which had been attacked by *Sahlbergella* some months previously, and he suspects that it is *Helopeltis* which prevents the recovery of the trees. The true status of *H. bergrothi* as a pest of the vegetative parts of cacao can only be ascertained by continuous observations during the rainy season. The writer has suggested that the study of *H. bergrothi* should be included in the entomological programme of the new Cacao Research Station at Tafo, in the Gold Coast. The bugs appear to be very numerous in that locality, for Wright¹⁶ has recorded that out of 457,752 pods harvested there (between September 1937 and February 1938) 193,741 bore *Helopeltis* lesions.

Cacao Die-back.

Voelcker & West²³ have given an account of the opinions held in various countries about the causative factors responsible for die-back. In Nigeria, they consider that there are two factors, one operating in the Ibadan district where rainfall is low (49 in.) and the other in the Ondo district where rainfall is higher (63 in.). These factors are lack of soil moisture during the dry season and *Sahlbergella* attack respectively. For the Gold Coast, the only theory quoted is that of Dade, who "holds that drought is the fundamental cause of die-back throughout the Gold Coast." There is no doubt that, whatever Dade's opinion may be about the causation of die-back, the entomologists¹ and farmers of the Gold Coast have long recognised the importance of *Sahlbergella*. In addition, Patterson¹⁹ has stated, with regard to *Helopeltis*, that "all the soft shoots may be repeatedly killed: thus the pest is one of the sources of 'die-back disease'."

Voelcker & West give the name "blast" to the damage caused by *Sahlbergella* spp. Amongst the diagnostic characteristics of blast they mention dead brown leaves remaining attached to the trees and small discoloured areas on the petioles and stems of young shoots in the process of wilting. In the writer's experience, the first of these symptoms can also be caused by root disease and the second by *H. bergrothi* attack.

A condition usually considered to be physiological die-back is common amongst cacao trees bordering a road to the south of Ibadan. In October 1939, the writer found that many of these trees had been attacked by thrips; lesions were very numerous on the leaves, many of which had been abscised, and all the pods were rusty-brown in colour. Trees more than about 15 yards from the roadside were unaffected. The role of thrips is obscure, but Cotterell² believes that these insects are of minor importance in the Gold Coast and that their attacks are entirely secondary to bad cultural conditions.

***Solanum verbascifolium*.**

When the forest is cleared at Owena (preparatory to cacao-planting) *Solanum* is amongst the first plants to spring up in the new farmland. Its seeds are bird-borne. It is also the commonest weed in the established cacao areas and grows wherever there is a break in the canopy. Its eradication is difficult and the local farmers content themselves with cutting back the plants two or three times during the rainy season. *Solanum* plants which happen to be growing in the areas surrounding rock outcrops are often left untouched; they attain a height of about 30 ft. with a bole nearly 6 in. across and ensure a supply of seed for birds to spread about the farms. The ratooned plants, growing in the actual farms, produce flushes of new growth which appear to be attractive to all the hemipterous pests of cacao (with the solitary exception of *Sahlbergella*) and to an Acridid, *Catantops simplex*, Uv., which is common on the leaves of young cacao trees. The plant bugs found attacking both cacao and *S. verbascifolium* were the following: —*Helopeltis bergrothi*, Reut., and *H. aestwoodi*, White (CAPSIDAE); *Piezosternum fallax*, F., and *Halyomorpha reflexa*, Sign. (PENTATOMIDAE); *Acanthocoris dentatus*, Hagl., and *Cletomorpha lancigera*, F. (COREIDAE); *Pochazia fasciata*, F. (RICANIIDAE).

Further research is required to ascertain the exact importance of *Solanum* as an alternative food-plant of cacao pests; with the exception of *H. bergrothi* and *C. lancigera*, none of the insects mentioned above was numerous on cacao at the time of the writer's visit to Owena.

Acknowledgments.

The writer wishes to express his indebtedness to Sir Guy Marshall and various specialists at the British Museum for identifying the insects mentioned in this paper and to Mr. T. W. Hussey, of the Nigerian Forestry Department, for identifying *S. verbascifolium*.

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COLLECTIONS RECEIVED.

The following collections were received by the Imperial Institute of Entomology between the 1st October and 31st December, 1940 :—

Mr. J. D. BRAITHWAITE, Forest Entomologist :—3 Parasitic Hymenoptera ; from Burma.

CORYNDON MEMORIAL MUSEUM, NAIROBI :—293 Diptera, 319 Coleoptera, 534 Hymenoptera, and 3 Orthoptera ; from East Africa.

Mr. W. COTTIER, Entomologist :—1 species of Mite ; from New Zealand.

FOREST PRODUCTS RESEARCH LABORATORY :—1 Cerambycid ; from England.

Mr. J. L. FROGGATT, Government Entomologist :—4 Diptera, 223 Coleoptera, 62 Parasitic Hymenoptera, 3 other Hymenoptera, 11 Lepidoptera, and 6 Rhynchota ; from New Guinea.

Mr. E. P. HODGKIN, Medical Entomologist :—22 Diptera and 8 pupa-cases ; from Malaya.

Mr. G. H. E. HOPKINS, Medical Entomologist :—11 Diptera ; from Uganda.

INDIAN MUSEUM, CALCUTTA :—1,470 Diptera ; from India.

Dr. K. H. L. KEY :—519 Orthoptera ; from Africa.

Dr. R. H. LE PELLEY :—175 Coccinellidae and 300 Formicidae ; from various localities.

Mr. R. A. LEVER, Government Entomologist :—3 Culicidae, 7 other Diptera, 102 Coleoptera, 101 Parasitic Hymenoptera, 34 Lepidoptera, 1 species of Coccidae, 2 species of Aleurodidae, 20 other Rhynchota, 2 Orthoptera, 2 Chrysopidae, and 200 Mites ; from Fiji Islands.

Dr. J. W. SCOTT MACFIE :—395 Diptera ; from England.

Mr. N. C. E. MILLER, Entomologist :—12 Curculionidae and 16 Orthoptera ; from Malaya.

Mr. F. S. PARSONS, Empire Cotton Growing Corporation :—100 Formicidae and 20 Isoptera ; from South Africa.

Mr. J. RISBEC :—31 Diptera and 3 pupa-cases, 1,324 Coleoptera, 928 Parasitic Hymenoptera, 18 other Hymenoptera, 24 Lepidoptera, 2 species of Coccidae, 352 other Rhynchota, 31 Orthoptera, 6 Dermaptera, and 2 Planipennia ; from Senegal.

Mr. E. R. SPEYER :—4 Spiders ; from England.

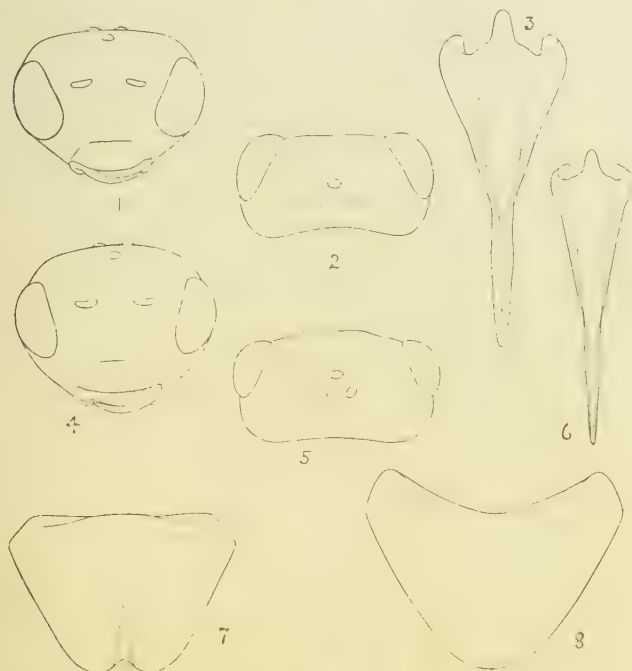
Mr. F. G. S. WHITFIELD :—3 Siphonaptera ; from England.

NEW BRACONID PARASITES OF *ANTESTIA LINEATICOLLIS*, STÅL,
AND OF *SYLEPTA DEROGATA*, F.

By G. E. J. NIXON, B.A.,
Imperial Institute of Entomology.

In this paper a short revision of the African forms of the genus *Aridelus* (formerly *Helorimorpha*) is given and one new species is described. Of the seven African species now known (some of which will almost certainly fall later as synonyms) three, including the new one, are parasites of the important Hemipterous pest of coffee, *Antestia lineaticollis*, Stål.

I have also included a new genus and species, probably belonging to the sub-family DIOSPILINAE, parasitic on the Cotton Leaf Roller, *Sylepta derogata*, F.



Figs. 1-8.

(1) *Aridelus taylori*, sp. n., ♀, head (from in front); (2) same (from above); (3) *A. coffeae*, Brues, stylet of ovipositor (dorsal); (4) same, ♀, head (from in front); (5) same (dorsal); (6) *A. africana*, Brues, stylet of ovipositor (dorsal); (7) *A. coffeae*, Brues, ♂, apical sternite; (8) *A. taylori*, sp. n., ♂, same.

Subfamily EUPHORINAE.

Aridelus, Marshall.

Aridelus, Marshall, 1887, Trans. Ent. Soc. London, **1887**, p. 66.

Hclorimorpha, Schmiedeknecht, 1907, Die Hymenopteren Mitteleuropas, p. 523.

Stictometeorus, Cameron, 1909, Soc. Ent. **24**, p. 9.

Erythrometeorus, Cameron, 1911, Timehri **1** p. 317.

Scipolabia, Enderlein, 1918, Arch. Naturgesch., A. **84** (10), p. 220.

The above synonymy is taken from Muesebeck (1936). I have every confidence in Dr. Muesebeck's reasons for establishing it.

It is obvious that on the form of the ovipositor the African species of *Aridelus* fall into two sharply defined groups. So striking indeed are the differences that it seems as though they should not be found in the same genus. On the other hand, there is no other character which would support a generic division. Unfortunately I do not know the male of one of the groups; when eventually discovered it may prove to differ from the males of the second group in some character comparable in magnitude with that which distinguishes its female. If this should be the case then I think it would be reasonable to split off another genus from *Aridelus*.

The African species known to me have the following characters in common :—

Head strongly transverse (figs. 2, 5). Mandibles long, falcate, with a slender apical tooth and with a large tooth proximal to this on the inner side. Clypeus and face always with a sculpture of close, uneven punctation. Frons with a sharp medial keel which extends from between the antennal sockets more or less to the anterior ocellus. Antenna with 18 segments; antennal socket separated from the eye-margin by about its own width; scape about twice as long as wide. Ocelli arranged in a triangle whose base is clearly longer than its sides. *Thorax*: Mesonotum sharply truncate in front; in a dorsal view fully twice as wide as long, finely pubescent, but the pubescence readily visible only when the mesonotum is seen slightly from in front; coarsely reticulate all over, the size of the meshes, on the whole, considerably greater than the area of a posterior ocellus; notaulices completely wanting. Propodeum a little hollowed out posteriorly, widely reticulated all over, the surface within the cells shining and more or less flat. Apical rim of the hind tibia with a completely differentiated, dense, silky fringe of fine hairs on inner half; and with a close row of fine bristle-like spines on outer half. *Abdomen*: Petiole long, narrow, only a little wider at extreme apex than across the spiracles, smooth, weakly elbowed at spiracles, which are situated a little distal to middle. Tergite (2+3) reaching virtually the apex of the abdomen, so that the latter (beyond the petiole) appears to consist of single large segment. Ovipositor hardly projecting beyond the apex of the abdomen, its sheaths bare.

*Key to the Species, ♀♀.**

1. Body entirely reddish yellow.....2
 Body with at least the thorax marked with black.....3
2. Flagellum blackish throughout.....*coffea*, Brues
 Flagellum bright reddish, except for the apical 4-5 segments, which are darkened
 *africana*, Brues
3. Thorax entirely blackish.....*taylori*, sp. n.
 Thorax with only the mesonotum, scutellum, postscutellum, and a patch on the
 mesosternum blackish.....*rufus*, Cameron

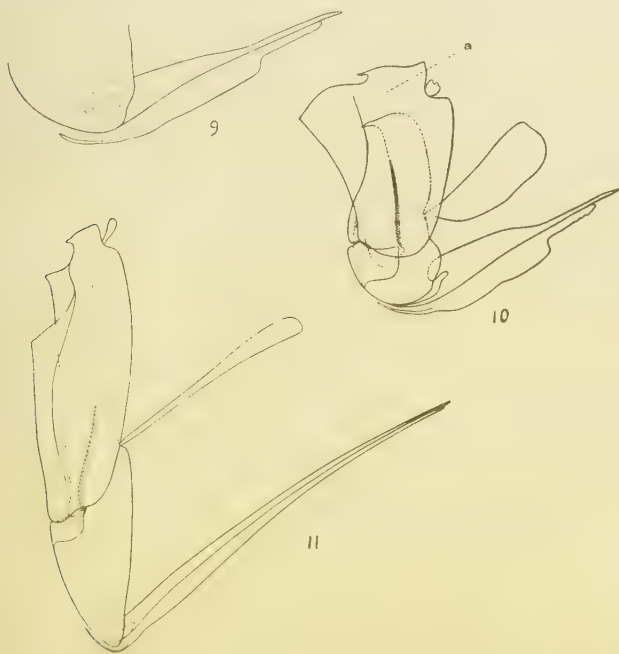
* Only those species known to me in nature are included in the key.

***Aridelus taylori*, sp. n.**

♀. Head reddish brown, paler on the face, darker on the vertex; thorax entirely blackish; abdomen, apart from the petiole, which is almost blackish, reddish brown. Antennae reddish yellow to brownish yellow with the apical 4-5 segments darkened. All the coxae and femora brownish; the hind pair of femora almost black; front and middle tibiae pale brownish yellow, the hind pair dark brown. Venation of the fore wing dark brown, except the 3rd abscissa of the radius, which is yellowish; that of the hind wing very pale, almost colourless.

Face and clypeus closely rugose-punctate; nowhere do isolated punctures occur. Eyes decidedly convergent below (fig. 1). Malar space about $2\frac{1}{2}$ times shorter than the long axis of the eye (9:23); in a dorsal view of the head the eyes bulge forwards beyond the line of the face (fig. 2). Vertex rather coarsely punctate-reticulate. Flagellar segments 13-15 rather short, about $1\frac{1}{4}$ times as long as their greatest width. Scutellum coarsely reticulated all over, not smoother in the middle. Abdomen beyond the petiole narrowly fusiform. Ovipositor projecting only very slightly beyond the apex of the abdomen; the ovipositor itself presents no unusual feature, except that it is very slender in comparison with the other species included in this paper; it is noteworthy that almost the whole of the long sheaths are concealed within the abdominal cavity; the entire structure, apart from the ovipositor itself, is remarkable in that the 2nd valvifers (Snodgrass) together form a deep pocket from the much narrowed bottom of which the ovipositor is articulated. Apical sternite not at all excised at apex.

Length: 3.5 mm.



Figs. 9-11.

(9) *Aridelus africana*, Brues, ovipositor of ♀; (10) *A. coffeae*, Brues, genitalia of ♀; (11) *A. taylori*, sp. n., genitalia of ♀.

UGANDA: Bubulu, xi.1938, 1 ♀, the type; Bupoto, xi.1938, 1 ♀; both females bred from *Antestia* (presumably *lineaticollis*) (T. H. C. Taylor).

The cocoon is thick, white, hard and somewhat rough in texture.

Type in the British Museum.

There is in the British Museum a single female with the data, Cape Province, Pondoland, Port St. John, x.1923 (R. E. Turner), which may possibly be distinct from *taylori*. The lower part of the face and all the coxae are honey-yellow; the eyes are slightly larger than in *taylori* and a little more convergent below. The genitalia are identical with those of *taylori*. I should prefer to see more material of this form before drawing any conclusion about it.

The three following species are all very closely related, differing from each other, as far as their external appearance is concerned, almost only in colour. They differ from *taylori* in the following respects: In a dorsal view of the head the eyes do not bulge forwards beyond the line of the face (fig. 5); and in a front view of the head the eyes are less convergent below; the apical sternite has its apical margin rather narrowly excised (fig. 7). The ovipositor is entirely different, being of remarkable form (fig. 10); the lancets in profile are strongly angled a little distal to middle; proximal to middle they are strongly dilated, especially in *coffea*, Brues, and *rufus*, Cameron; the swollen part of each stylet consists of a hollow chamber with strongly sclerotised walls; at the basal end of the chamber and on its inner, flattened side is a circular opening, covered by a slightly larger, circular membranous flap. I do not know the physiological significance of this last-mentioned structure, but I think it is worth placing on record.

***Aridelus coffea*, Brues.**

Helorimorpha coffea, Brues, 1924, Ann. S. African Mus., **12**, p. 103, ♂.

When Brues originally described this species he did not know what its host was. It is now known to be a common parasite of *Antestia lineaticollis*, Stål.

The ovipositor is shown in fig. 10 and a dorsal view of the stylet in fig. 3; when the ovipositor itself is seen from above the swollen part of the lancets bulges considerably beyond the outline of the stylet.

UGANDA. KENYA. The type locality is Kenya, Kalesto.

This species is readily recognisable by its bright red-yellow colour and black flagellum.

***Aridelus africana* (Brues), new combination.**

Helorimorpha africana, Brues, 1924, Ann. S. African Mus., **12**, p. 101, ♂.

There is a single male in the British Museum identified by Brues as *africana*, and I have interpreted the species on the basis of this specimen.

♀ (hitherto unknown). The only external difference between *africana* and *coffea*, as far as I can see, lies in the coloration of the antennae (see key).

The ovipositor of *africana* is much like that of *coffea*, but there appear to be some appreciable points of difference; the lancets are much less swollen and in a dorsal view of the ovipositor itself they hardly bulge beyond the outline of the stylet (figs. 6, 9).

NATAL: Weenen, v.1924, 1 ♂ (H. P. Thomasset), det. by Brues as *africana*. S. ZULULAND: Gingindhlovu, vii.1926, 1 ♀ (R. E. Turner). CAPE PROVINCE: Pondoland, Port St. John, iv.1923, 1 ♀, vii.1923, 1 ♀ (R. E. T.).

The species was described originally from Zululand, M'fongosi.

Aridelus rufus (Cameron), new combination.

Stictometeorus rufus, Cameron, 1909, Soc. Ent., **24**, p. 9, ♀.

Helorimorpha rufa, Cameron, Brues, 1924, Ann. S. African Mus., **12**, p. 101.

This is the species which Kirkpatrick (1937) figured and discussed as "*Helorimorpha* sp." Material bred by him from *Antestia lineaticollis* and sent to the Imperial Institute of Entomology for identification was later determined by D. S. Wilkinson as *Helorimorpha rufus*, Cameron.

A. rufus is extremely closely related to both *coffear* and *africana*. It differs from both strikingly in colour, but in all other respects there is close agreement. The ovipositor appears to be in every way identical with that of *coffear*. Size a little smaller than *coffear* (about 3.6 mm.), and the pale parts of the body yellowish in tint rather than reddish. The first 5-6 segments of the flagellum are dull brownish red; the apical 2-3 segments are dark brownish, while the intervening segments are usually decidedly yellowish; the flagellum thus has frequently a marked tri-coloured appearance. The abdomen of the male beyond the petiole is usually brownish.

TANGANYIKA: Amani, 1936-37 (*T. W. Kirkpatrick*).

Species of *Aridelus* not known to the writer:—

1. *Aridelus bicolor* (Szépligeti).

Stictometeorus bicolor Szépligeti, 1913, Ann. Mus. Nat. Hungarici, **11**, p. 608, ♀.

Helorimorpha bicolor (Szép.), Brues, 1926, Studies on South African Braconidae, Proc. Amer. Acad. Arts Sci. **61** (8), pp. 301 & 422.

"Schwarz; Kopf (in der Mitte oben schwarz), Schaft, Prothorax und Tegula gelbrot; die Naht zwischen Meso- und Metathorax rot; Beine und Hinterleibsstiel gelb; 2. Segment rotbraun, oben braun. Endsegmente gelbrot. Flügel und Grösse wie bei *St. luteus* m.

"Deutsch-Ostafrika: Moshi (Katona)."

From the above description this must be a very striking-looking species and is probably distinct from any of those I have included in the key.

2. *Aridelus cameroni* (Szépligeti).

Stictometeorus cameroni, Szépligeti, 1914, Mitt. Zool. Mus. Berlin, **7**, p. 229, ♂.

Helorimorpha cameroni (Szép.) Brues, 1926, Studies on South African Braconidae, Proc. Amer. Acad. Arts Sci. **61** (8), p. 422.

"Kopf quer, scheibenförmig, hinter den Augen gerundet und punktiert; Stirn und Scheitel runzlig, Gesicht und Clypeus dicht punktiert. Zwischen den weit stehenden Fühlern ein kleiner Zapfen; Fühler 18-gliedrig, die 2 ersten Grundglieder lang, die folgenden bedeutend kürzer und abgerundet. Thorax zellenartig runzlig, Parapsiden und Sternaulen fehlen, Scutellum breit und flach, Metanotum eingedrückt. Seiten des Randmals fast gleichlang, Radialzelle kurz, Radialader besteht fast nur aus 2 Abschnitten, indem der 2. Abschnitt ganz kurz ist, der 3. Abschnitt läuft mit dem Rande des Randmals parallel, N. recurrens interstitial, Nervulus schwach postfurkal. 1. Segment stielförmig, gebogen, fast so lang wie das 2.; die folgenden Segmente verborgen. Hinterleib glatt.

"Schwarz; Gesicht, Augenrand, Fühler fast ganz, Beine und Hinterleib rot; Petiolus und Postpetiolus unten schwarz. Flügel hyalin, Ende etwas bräunlich, Randmal braun.

"Länge: 5 mm.

"Deutsch-Ostafrika, Amani, xi. 1906 (Chr. Schröder)."

3. *Aridelus luteus* (Szépligeti).

Stictometeorus luteus, Szép., 1913, Ann. Mus. Nat. Hung., **11**, p. 608, ♀.

Helorimorpha luteus, Szép., Brues, 1926, Proc. Amer. Acad. Arts Sci. **61** (8), pp. 301 & 423.

"Kopf quer, hinter den Augen erweitert, punktiert, Clypeus geschieden, Gesicht breit; Ocellen klein. Fühler 18-gliedrig, Endglieder rund Thorax kurz, kaum länger als hoch, runzlig. Parapsiden und Furche der Mesopleuren fehlen; Metathorax eingedrückt, senkrecht gestützt; Luftloch klein. Randmal kurz und breit, mit gleichen langen Seiten; erster Abschnitt der Radialader fast doppelt länger als der 2., und länger als die 2. Cubitalquerader, der 3. Abschnitt leicht gebogen und endet in der Mitte des Metacarp; N. recurrens an die Areola inseriert, die oben zusammengezogen ist; Nervulus postfurkal, zweite Diskoidalzelle offen. Beine schlank, Hüften kurz, dreiseitig, Sporne kurz. Erstes Segment stielförmig, Ende dicker und gebogen; 2. Segment gross, länger als das 1., glatt; die folgenden kurz und z.T. verborgen, Endsegmente oben ausgeschnitten.

"Gelbrot; Flagellum schwarz. Flügel hyalin, Nerven z.T. und Randmal schwarz.

"Länge 4 mm.; Bohrer kurz.

"Deutsch-Ostafrika: Moshi (Katona)."

This species is probably identical with *Aridelus coffeae*, Brues.

Subfamily DIOSPILINAE.

The insect described below is of special interest because of the remarkable modifications shown by the apical segments of the female abdomen.

Benama, gen. n.

Apical margin of the clypeus simple. Mandibles bidentate. Eyes large, the malar space so short as to be almost absent. Ocelli large, the distance between a posterior ocellus and the eye-margin only a little greater than its longer axis. Maxillary palpi 6-segmented; labial palpi 4-segmented.

Thorax with complete notaulices. Legs slender; hind tarsus not shorter than its tibia; hairs of the tibia long, outstanding (by comparison with *Diospilus*, Hal.). Fore wing: 2nd cubital cell very slightly narrowed above; 1st discoidal cell not stalked. Abdomen of the female with 6 exposed tergites.

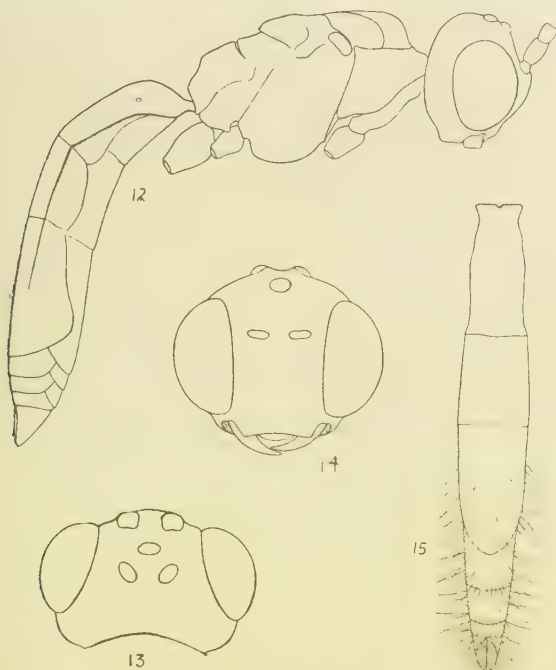
Type of the genus: *Benama hutsoni*, sp. n.

Benama hutsoni, sp. n. (fig. 12).

♂. Head and thorax, except the propodeum, which is brown, honey-yellow; petiole, tergite 2 (discrete), about basal half of 3, brownish; the brown patch on tergite 3 is subtriangular in the female, subquadrate in the male; rest of the abdomen honey-yellow. Flagellum pale brownish, paler towards base; scape and pedicel honey-yellow. Legs honey-yellow. Wings hyaline, the stigma almost colourless; the venation of the hind wing is very indistinct. Palpi whitish yellow.

♀. Head transverse, rather large, clearly wider than the thorax across the tegulae (7:6) and considerably narrower behind the eyes than across them (fig. 13). Eyes very large, almost reaching the base of the mandibles, the malar space extremely short (fig. 14). Ocelli large, arranged in a triangle whose base is a little longer than its sides; distance between a posterior ocellus and the eye-margin about $1\frac{1}{4}$ times the longer axis of the ocellus. Clypeus about twice as wide as long, separated from the face only by a shallow depression; its apical margin shallowly emarginate; its base with a smooth, transverse swelling. Face rather prominent beneath the

antennal insertions, shining, with rather feeble, isolated punctures, which are also present on the clypeus. Margin of the occiput narrowly obliterated above. Antenna with 28-30 segments, 30 (5), 28 (3), 29 (1); pedicel about two-thirds the length of the scape; flagellum decidedly slender. *Thorax*: Mesonotum falling rather steeply to the pronotum, strongly shining, smooth except for a few, isolated, small, indistinct punctures; notaulices sharply defined, complete throughout, but widely separated posteriorly, foveolate; between them posteriorly two short, sometimes indistinct, linear furrows. Scutellum feebly convex, its anterior depression divided by a single ridge into two large foveae. Propodeum reticulate-rugose and without clearly defined areation; an areola is usually present, but its limits often ill defined; a more or less emphasised crest-like ridge divides the dorsal surface from the posterior face. Mesopleural furrow varying in definition; when well defined, costate; when ill-



Figs. 12-15. *Benama hutsoni*, gen. et sp. n., ♂: (12) body (lateral); (13) head (from above); (14) head (from in front); (15) abdomen (dorsal).

defined, then made up of a number of foveae in more or less haphazard arrangement; mesopleura otherwise smooth, except for traces of punctures. Legs rather slender; hairs of the hind tibia long, those on the upper surface about two-thirds the middle width of the tibia; hind tarsal segment 3 a trifle longer than 5. 1st abscissa of the radius of the fore wing as long as the 2nd (fig. 16). *Abdomen* long, narrow (fig. 15), the apex of tergite (2+3) and the following tergites compressed laterally; this compression is least noticeable when tergites 4-6 are fully retracted; these tergites can be exerted to equal twice their combined length as shown in the figure; figure 15 was drawn from a female in which tergites 4-6 appear to be almost fully retracted; tergite 1 about $2\frac{1}{2}$ times as long as apically wide, rugose-reticulate with longitudinal

elements laterally ; tergite (2+3) divided by a fine suture into its two morphologically separate segments, tergite 2 having fine, very shining, confused, longitudinal striation and 3 being completely smooth ; tergite 2 throughout and 3 to about middle with a completely differentiated lateral margin. The compressed, apical part of the abdomen thickly clothed with long, pallid, bristly hairs. Genitalia (fig. 18) : the ovipositor completely enclosed within the apex of the abdomen ; its sheaths cupped within the apical sternite and visible only in a dorsal view of the abdomen ; they present a short, oval configuration, the shaded area in fig. 15.

Length : 3.3 mm.

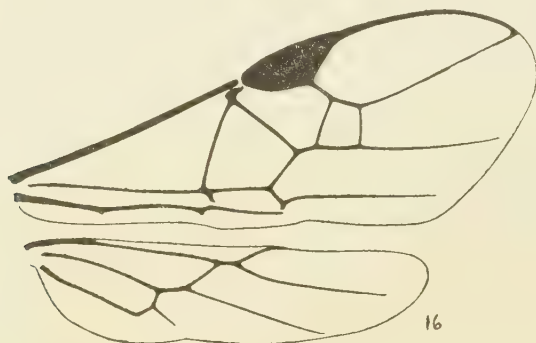


Fig. 16. *Benama hutsoni*, gen. et sp. n., wings, ♀.

Morphology of the 7th and 8th tergites (the abdomen of the clistogastrous Hymenoptera is here meant) and of the genitalia of the female.—In the abdomen of the Braconid female, generally speaking, eight tergites can be made out ; these consist of (1) a more or less differentiated 1st tergite (the true 2nd tergite of the insect abdomen), frequently referred to as the petiole ; (2) a large 2nd segment, made up of the fused 2nd and 3rd tergites ; and (3) five free tergites. The 8th or apical tergite (the true 9th) forms a kind of sheath partly enclosing the genital structure (*cf.* fig. 10, *a*) ; antero-ventrally, it is articulated on each side with the dorsal (anterior) angle of the 1st valvifer. The 7th tergite (the true 8th) is of ordinary form and not in any way differentiated from the 6th and 5th.

In *Benama hutsoni*, sp. n., the 7th tergite is almost completely split along the middle line, the two halves being narrowly joined anteriorly (fig. 17) ; in the 8th tergite longitudinal division has been complete and each half has been modified to form a narrow, greatly elongated structure (18*a*) which projects forward freely into the abdominal cavity ; it is blade-like in thickness, widened at apex and shows a resemblance to a golf-club. The 2nd valvifer (*b*) anterior to its articulation with the 1st valvifer is similarly elongated, but the structure here is more blade-like in appearance as well as in thickness. The 3rd valvulae (known to hymenopterists as the sheaths of the ovipositor) are articulated with the 2nd valvifers at the point (*c*). The bulb of the stylet is produced forward in the form of a narrow rod (*d*).

♂. Like the female, except that the apex of the abdomen shows no lateral compression. Genitalia (fig. 19).

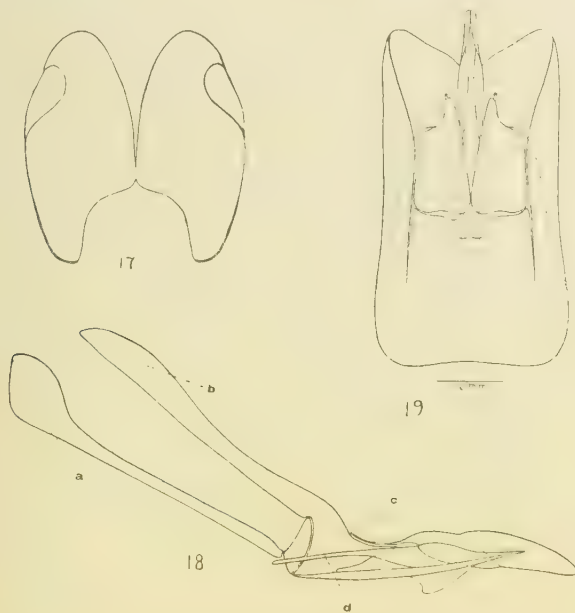
Length : 3 mm.

CEYLON : Embilipitiya, 11 ♀♀, one the type, 1 ♂ (ser. no. 8768), bred 2.ii.1937 from larva of *Sylepta derogata*, F. (Pyralidae).

Type in the British Museum.

I have assigned this genus to the DIOSPILINAE, where, if the remarkable modifications of the apical abdominal segments of the female be left out of account, it appears quite naturally to belong. Among the genera of this subfamily it appears to resemble most closely *Diospilus*, Haliday, having like that genus a clypeus of simple form and the 1st discoidal cell of the fore wing not petiolate. But I do not suggest that these two points of similarity necessarily imply a closer relationship to *Diospilus* than to any other genus in the subfamily. *Benama* differs in both sexes from *Diospilus* in having much larger eyes, larger ocelli, together with their much greater proximity to the eye-margin; in having the 1st abscissa of the radius as long as the 2nd and longer vestiture on the tibiae (in *Diospilus* it is very short and much denser), and in having the hind tarsus as long as its tibia.

Diospilus has the abdomen of the female consisting of eight freely-exposed tergites and the genitalia are of ordinary form.



Figs. 17-19. *Benama hutsoni*, gen. et sp. n.: (17) tergite 7 (folded out), ♀; (18) genitalia of ♀; (19) genitalia of ♂ (ventral).

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HELOPELTIS (HEM., CAPSIDAE) ON CINCHONA.

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The observations here recorded have been made between April and October 1940, at Amani, Tanganyika Territory.

Two distinct varieties of *Helopeltis* occur on cinchona at Amani, which correspond well with the descriptions of *H. bergrothi*, Reut. var. *rubrinervis*, Popp., and *H. bergrothi* var. *disciger*, Popp. (Poppius, 1911). They may be readily distinguished as follows:—



Fig. 1. *Helopeltis bergrothi*, Reut. var. *rubrinervis*, Popp.: (a) hemielytron; (b) hind wing ($\times 20$).

Var. *rubrinervis*.—Head, thorax and abdomen all orange-red, except for a shining black pear-shaped spot on the head between the antennae. Hemielytron (fig. 1, *a*), yellow-orange with a broad dark grey band across the middle half of the corium and clavus; cuneus almost black; membrane dark grey, except for a large yellowish spot approximately in the centre. Hind wing (fig. 1, *b*), yellow with two broad grey transverse bands.

Var. *disciger*.—Head entirely shining black, except at the extreme posterior margin; thorax orange-red, except for a dark median line on pro- and meso-thorax (this is more distinct in the male than in the female); scutellum mainly dark. Hemielytron (fig. 2, *a*) with the base of corium yellow, but the remainder almost as black as the cuneus; membrane entirely dark grey. Hind wing (fig. 2, *b*) all grey except at base.

No intermediate forms have been found in the field or bred in the laboratory. I have been unable to distinguish the immature stages of the two varieties.

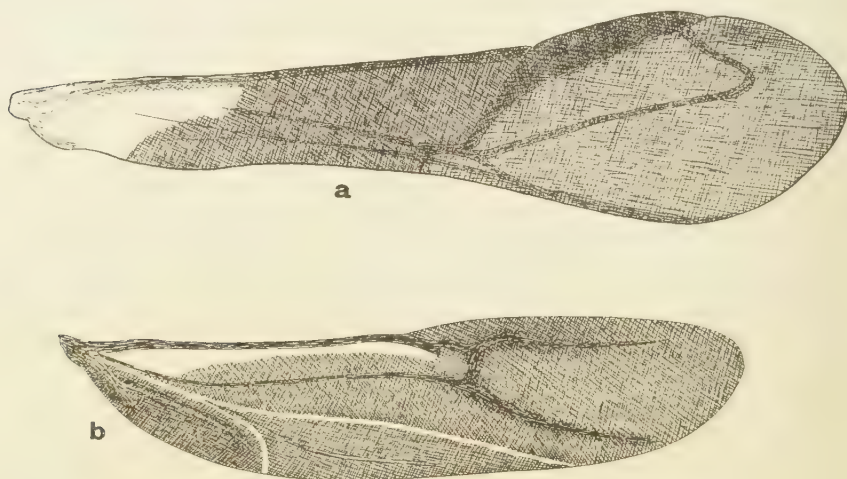


Fig. 2. *Helopeltis bergroethi* var. *disciger*, Popp.: (a) hemielytron; (b) hind wing ($\times 20$).

Genetical Data.

The following results of breeding experiments show that *disciger* is a simple Mendelian recessive to *rubrinervis*:—

No.	Parents		No. of families	Total offspring				Assumed genotype of parents	
	♀	♂		<i>rubrinervis</i>		<i>disciger</i>			
				♀	♂	♀	♂	♀	♂
1	<i>rubrinervis</i>	<i>rubrinervis</i>	4	28	25	—	—	One or both RR	
2	<i>rubrinervis</i>	<i>rubrinervis</i>	3	46	58	18	21	Rr	Rr
3	<i>disciger</i>	<i>rubrinervis</i>	1	4	4	—	—	rr	RR
4	<i>rubrinervis</i>	<i>disciger</i>	2	44	40	—	—	RR	rr
5	<i>disciger</i>	<i>rubrinervis</i>	5	40	37	40	40	rr	Rr
6	<i>rubrinervis</i>	<i>disciger</i>	3	16	14	28	24	Rr	rr
7	<i>disciger</i>	<i>disciger</i>	—	—	—	67	45	rr	rr
Total				178	178	153	130		

All pairings, except 6 and 7, give ratios which agree with expectation from the assumed genotypes. The ratio of *rubrinervis* : *disciger* progeny from cross 6 departs rather widely from the 41 : 41 ratio expected from the assumed genotype of the parents : $\chi^2=5.9$ which, for $n=1$, gives P slightly less than 0.02. The reasons for the discrepancy, if really significant, are unknown. In cross 7 the proportion of ♀♀

appears to be somewhat high, for the total of all the other families (including some from wild *disciger* females, male parent not known) was 110 ♂ to 114 ♀ *disciger*. If the same ratio has been observed in this crossing there would have been 55 ♂ to 57 ♀; χ^2 is 3.57, which for $n=1$, gives P slightly over 0.05. If this is significant it may partly account for the fact that, in the field, the recessive *disciger* appears to be at least as numerous as the dominant *rubrinervis*.

Food-plants.

I have not found either variety on any plant except cinchona. However, according to Poppius (1911) var. *disciger* was recorded by Vosseler at Amani on *Bixa* and *Ricinus*, and var. *rubrinervis* on *Ricinus*, as well as on cinchona. But at the present time there is no trace of *Helopeltis* on the numerous plants of *Bixa* or the few of *Ricinus* that are growing at Amani. Nor is there now any sign of it on cacao at Sigi, below Amani, although the record of a *Disphinctus* sp. on cacao in this locality (Vosseler, 1906) almost certainly refers to a species of *Helopeltis*.

Harris (1937), writing about *Helopeltis bergrothi** on cotton in Tanganyika Territory, gives a wide range of food-plants. I have tried to rear nymphs (the parents of which had been bred on cinchona) on *Bixa*, cotton and tea, but though they fed on these plants and produced typical lesions (only very small ones on *Bixa*) none of the insects survived for more than a few days.

All the species or varieties of cinchona grown at Amani are attacked, but there is some indication that *robusta*, *succirubra*, and a narrow-leaved variety of *ledgeriana* from Java, are less extensively attacked than an Indian strain of *ledgeriana* with broader and larger leaves, a hybrid *succirubra* \times *ledgeriana*, and *josephiana*. It is possible, however, that the difference is due more to the age of the plants than to the varieties, for they are not all of the same age and younger plants appear, as a rule, to be preferred.

The nature of the injury is the same on cinchona as on other plants, and has been described by Harris (1937). While it is difficult to estimate accurately the *Helopeltis* population of any plantation, I believe that on one plot at Amani where severe injury was caused the average number present was not in excess of one adult and one or at most two nymphs per tree, and may well have been less than this. I have counted the number of lesions produced daily by a single third-instar nymph: they varied from 60 to 140, with an average of about 85. It is therefore not surprising that a very small population is sufficient to cause conspicuous injury.

Life-history.

This has been briefly described for *H. bergrothi* on cotton in Nigeria by Lean (1926) and in Tanganyika Territory by Harris (1937). There are, however, some differences in the life-history on cinchona at Amani, as might be expected from the different climate and host-plant; the more important facts will, therefore, be summarised here. They appear to be the same for both varieties.

The eggs are inserted deep into the plant tissue, only the operculum and the two chorionic processes being exposed (fig. 3). They are usually laid in the younger and softer branches, or in the leaf-petiole, or in the actual midrib of the leaf, but not further than about one inch from the base of the leaf. When laid in a petiole or mid-rib they are nearly always on the lower side. Oviposition occurs at any time of the day and, I think, also during the night. The deposition of one egg takes between

* The variety is not stated, but Harris (*in litt.*) has informed me that the specimens he has seen "from cotton, tea, etc., in Tanganyika Territory agreed well enough with the description of var. *disciger*." More recently he has kindly sent me a few specimens from cotton at Morogoro. These comprised both *disciger* and *rubrinervis*.

two and ten minutes as a rule, though I have seen one female that kept its ovipositor inserted for over two hours while laying a single egg. One would expect the insect to be extremely vulnerable to the attacks of predatory enemies during such a lengthy oviposition process.

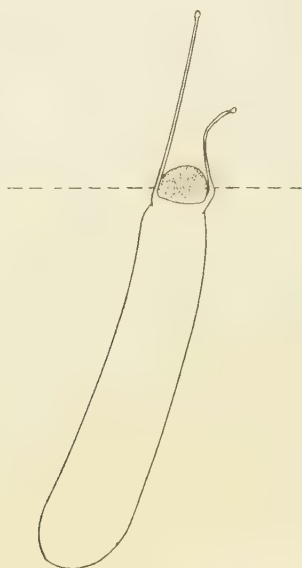


Fig. 3. *Helopeltis bergrothi*: egg ($\times 34$).

The incubation period of the egg, in the laboratory, varied from 16 days in April at an average temperature of 23°C . to 23 days in June at an average temperature of 21.4°C . It is no doubt less during the warmer weather of January to March. In the laboratory only slightly over 50 per cent. of the eggs hatched. They were laid in cut stems, the bases of which were kept in a tube of water, but I do not think that this low percentage is entirely due to some of the stems tending to dry up, for eggs have been observed to hatch successfully in very dry twigs as well as in those that had remained fresh. The process of hatching takes about five minutes, and is quite similar to that described and figured for *Cimex* by Wigglesworth (1939, p. 13). After the nymph has got free, the embryonic membrane is left protruding from the empty egg-shell, which itself remains buried in the plant tissue. Considerably more than half the eggs hatch between 3.0 and 5.0 p.m., a few may hatch between 5.0 p.m. and the following morning, and only a very few between 8.0 a.m. and 2.0 p.m. The young nymph starts to feed a few minutes after hatching, and typical lesions, though smaller than those made by older nymphs and adults, are produced at once.

The total duration of the five nymphal stadia is, in the laboratory, from 22 to 27 days in April and May, and 30 to 35 days in June and July. I have not observed copulation among adults until nine days after the final ecdysis, and the pre-oviposition period of the adult female is about twelve days and sometimes longer. The following table gives two typical examples of the life-history:—

	Duration of stadium, in days						Pre-oviposition period	Total, egg to first egg
	Egg	1st	2nd	3rd	4th	5th		
April-May ...	17	4	3	4	5	6	12	51
June-July ...	23	4	5	7	7	10	12	68

I have found that the number of eggs laid, at least in the laboratory, is greatly in excess of that recorded by previous workers, viz., about 50 (Lean, 1926), and an average of 30 (Steyaert & Vridagh, 1933).

The number laid daily by one female is very variable, the maximum is eight (just possibly nine), but there are often days on which only one or none is laid.

The following table gives the total number of eggs and length of oviposition period for 7 ♀♀ of *rubrinervis* and 11 ♀♀ of *disciger* :—

(1) *rubrinervis*

Total eggs laid	Duration of oviposition period (days)	Average number of eggs laid daily
251	125	2.01
239	91	2.63
184	49	3.75
182	81	2.25
178	93	1.91
82	35	2.34
70	53	1.32
Average 169	75	2.25

(2) *disciger*

409	106	3.86
289	81	3.57
286	96	2.98
247	113	2.19
204	97	2.11
197	107	1.84
172	79	2.18
138	46	3.00
99	41	2.42
94	35	2.69
91	62	1.47
Average 202	78	2.58

The difference in fecundity between the two varieties is clearly not significant from the above data; but if *disciger* is in reality more fecund than *rubrinervis* this would help to account for the fact that the recessive is, as already stated, no less common in the field than the dominant.

It is probable that in the field the number of eggs laid, or at least the number that hatch, is very much less than it is in the laboratory. The reason for this is unknown ;

possibly there is an efficient egg-parasite which has, so far, escaped my notice, or, more probably, the average duration of the life of the adult female is much reduced under natural conditions.

Copulation, which lasts about two or three hours, is repeated at occasional and irregular intervals during adult life. It is doubtful whether more than a single act of copulation is necessary, for fertile eggs have been laid by a female for 78 days after the death of the only male to which it had had access. Unfertilised females lay a normal number of eggs, which are sterile.

Little is known about the seasonal prevalence of *Helopeltis* on cinchona. It was certainly much less common in June and July 1940 than it was during the warmer weather of January to April; very little fresh damage was being done and the bushes were recovering rapidly from the severe set-back they received at the beginning of the year. There was, however, some increase during August and September.

Natural Enemies.

I have recorded two species of parasites from *Helopeltis* at Amani. One of these is a Braconid, probably of the genus *Euphorus*. This is a primary parasite, about which the following information has been obtained. It will oviposit in a nymph of any instar except the first. It will also apparently sting an adult, but I have no record of the larva developing in a host that was already adult when stung. The ovipositor is thrust into the side of the abdomen of the host and withdrawn after about one second. Between 16 and 21 days later (the period having no obvious relation to the temperature) the full-grown larva leaves the host through the dorsum of the abdomen and spins a tough white cocoon. The larva leaves its host some time during the night, and if it has not spun by 8.0 a.m. in the morning it usually fails to do so and dies a day or two later. If soil is available the *Euphorus* larvae burrow into it for pupation, but in the laboratory over two-thirds of those emerging failed to pupate, irrespective of whether they were given dry soil, damp soil, or no soil at all. Several of those that died were parasitised by the *Stictopisthus* mentioned below, but it seems unlikely that a secondary parasite would be the cause of the premature death of its primary. The adult emerges about 20–23 days after the cocoon has been spun, and is capable of oviposition on the day of emergence. Virgin females oviposit readily, but have produced only male offspring. The total life-cycle, egg to egg, is therefore about 36–44 days. I have kept the adults alive for eleven days, feeding them on sugar solution.

The effect of this parasite on its host is rather remarkable. If the host is stung while in the second or third (and possibly fourth) instar, the parasite larva leaves the host before it has become adult (there is some evidence that parasitism prolongs the duration of the stadium). Such a host never moults after the parasite has left it, and it dies between one and eight days later. If, however, a fifth (and probably fourth) instar host is stung it becomes adult before the parasite larva emerges. Although a few such hosts have died a week or so later, the majority recover and are able to copulate and oviposit. For example, from a pair of var. *rubrinervis* collected in the field a parasite larva emerged from the male on 16.v.40 and from the female on 19.v.40. Oviposition started on 5.vi.40, and a total of 171 eggs was laid: the female died on 16.ix.40, and the male on 19.viii.40. They had several times been observed *in copula*. Thus the male lived for 95 days after the emergence of its parasite, and the female for 120 days. An almost normal percentage (48 per cent.) of these eggs hatched.

Again, a pair of var. *disceiger*, bred in the laboratory, were experimentally parasitised on 1.vi.40 when they were 5th instar nymphs. Both became adult on 8.vi.40, and a parasite larva left the female on 18.vi.40 and the male on 19.vi.40. Oviposition started on 30.vi.40 and 147 eggs were laid by 21.ix.40, when the female died. 51 per cent. of these eggs hatched.

This ability to recover from parasitism is in striking contrast to the invariable mortality caused by some other species of EUPHORINAE, e.g., *Aridelus* (*Helorimorphus*) sp., a parasite of the Pentatomid, *Antestia* (Kirkpatrick, 1937) ; and *Euphorus pallipes*, a parasite of the Capsid, *Calocoris norvegicus* (Brindley, 1939).

The other parasite is an Ichneumonid belonging, I think, to the genus *Stictopisthus*. There is no doubt that this is usually hyperparasitic, and I have no good evidence that it is ever primary. It will, however, readily sting fourth and fifth instar *Helopeltis* nymphs that are known not to be already parasitised by *Euphorus*. The parasite mounts on the back of the nymph and stings it on the dorsum of the abdomen, the ovipositor being inserted for several seconds. I have had 26 such nymphs stung by this parasite in the laboratory. Two of these were dissected shortly afterwards and no egg was found in them ; the remainder were kept, no parasite developed in any of them, and they apparently suffered no ill effects from the sting, for they bred normally and their eggs were fertile.

Two explanations of this are possible. The *Stictopisthus* may be an obligatory hyperparasite, but only able to ascertain whether the necessary *Euphorus* larva is present by actually stinging the host. Alternatively, since it is not certain that the *Stictopisthus* used in this experiment were fertilised (one had been enclosed with a male, but copulation was not observed ; one was known to be virgin), it is possible that virgin females, although they sting readily, are incapable of laying eggs. The first hypothesis is considered the more probable, especially seeing that Menzel (1926) has recorded a species of *Stictopisthus* (*javensis*, Ferr.) as hyperparasitic on *Euphorus helopeltidis*, Ferr., on *Helopeltis antonii*, Sign., in Java.

Artificial Control.

While experimenting with the parasites it was noticed that *Helopeltis* nymphs introduced into the small cages in which the parasites were kept rapidly found and fed on the sugar solution provided for the parasites. It therefore seemed that a sweetened poison bait might prove effective and, judging from small-scale cage experiments, this is so. Two poison baits have been tried :—

(1) Sodium arsenate at the strengths of $\frac{1}{2}$ oz., 1 oz. and 2 oz. sodium arsenite, 5 lb. sugar, 4 gallons water. The first of these, though effective immediately after application, lost its efficiency after a single night's dew-fall : the third proved to be unnecessarily strong and caused some scorching of the leaves ; most experiments were therefore made with the intermediate strength.

The following are the results of typical experiments :—

(a) A cinchona bush, about 4 feet high, sprayed in the field with about 5 cc. of the bait, from a flit pump. A branch picked at random from it and put in a cage with 37 adult *Helopeltis* : 20 died within 48 hours, 10 more within 72 hours, and the remaining 7 within 5 days.

(b) A similar experiment, using about 3 or 4 times as much bait ; 59 out of 69 adults died within 24 hours, the remaining 10 within 48 hours.

(c) A single small drop of the bait placed on the upper surface of each of five leaves of a branch with about 20 leaves ; 18 out of 20 adults died within 5 days, 2 remaining alive.

(d) Similar, but the 5 drops placed on the lower surface of the leaves ; 19 out of 20 adults died within 5 days, 1 remaining alive.

In these experiments fresh cinchona twigs were given as required, but the original sprayed twig was left in the cage. There were no deaths among a large number of bugs kept as controls in similar cages without the poison bait.

(e) A piece of blotting paper, about 1 in. square, projecting from a corked tube containing the bait at the strength of 2 oz. to 4 gallons was put in a cage with abundant

fresh cinchona twigs and 45 adult bugs. About 6 to 8 of these died daily, and at the end of 7 days only 1 remained alive.

Only small numbers of nymphs have been available, but such experiments as have been made show that they also are attracted to the bait and succumb as readily as adults.

(2) A similar sweetened bait containing 0.4 per cent. by weight of sodium fluoride was quite ineffective; neither nymphs nor adults were killed by it. Presumably sodium fluoride is repellent and the insects will not feed on it.

Owing to the small numbers of *Helopeltis* now present no opportunity of testing the arsenic bait in the field has yet occurred, but I believe that, since it seems to be definitely attractive, a very light application would, during dry weather, probably give good results. Two applications at an interval of about three weeks would be necessary.

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NEW AFRICAN AND ORIENTAL SPECIES OF *MICRODUS*, NEES, FROM KNOWN HOSTS (HYMENOPTERA, BRACONIDAE).

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In this paper four new species are described and two already known ones are discussed. The justification for bringing forward new species in a genus whose Old World members are in a state of great disorder lies in the fact that their hosts are known and are Lepidopterous pests of economic importance.

The types are in the British Museum.

Subfamily AGATHINAE.

Microdus fabiao, sp. n.

♀. An entirely black species to the naked eye, the sides of the thorax in some lights appearing silvery grey, owing to the presence of large tracts of dense pubescence. Head and thorax entirely black, except that the pronotum and scutellum are dull reddish piceous; abdomen black, but the ventral surface to as far as the apex of sternite 2 (roughly basal half) yellowish red (some discoloration may have taken place). Palpi honey-yellow. Antennae black throughout. Hind legs black throughout, but the articulations of the tarsal segments faintly paler; hind spurs whitish yellow; middle legs mostly blackish, but the apex of the femora and the base of the tibiae brownish; the apical 4 tarsal segments extensively pale; front tarsi and tibiae honey-yellow. Wings nearly hyaline.

Head seen from above not sharply cut away behind the eyes, narrower than the thorax across the tegulae (43: 47), its posterior corners roundly angled (figs. 3, 4). Face and clypeus densely clothed with short, silky, silvery grey pubescence; face, clypeus and cheeks evenly and densely covered with small, rather sharp punctures which are separated by about one diameter. Frons very shining, with vague, large, more or less punctiform impressions. Vertex on each side of the ocelli deeply and, relatively very coarsely, punctate-reticulate. Antenna with 33 segments, stout, tapering to apex, at least the 22nd to the 32nd segments not longer than wide; flagellum 1 a trifle shorter than scape plus pedicel (9: 10); scape short, about $1\frac{1}{2}$ times as long as its greatest width. Labrum short, transverse. Ocelli arranged in a triangle with base much longer than sides; a tangent drawn at right angles to the long axis of the median ocellus just touches the anterior margin of the lateral ocelli; ocell-ocular line $2\frac{1}{2}$ times as long as the longer axis of a posterior ocellus. Segment 3 of the labial palpi not particularly short, about two-thirds as long as the 4th. Frontal hollows sharply margined in front, medially ending in a blunt process which is not prolonged towards the anterior ocellus as a carina. *Thorax*: Pronotum with only a shallow, unmargined impression on each side of the collar; its sides with a strong, thick, more or less straight carina which extends from just behind the impression on the collar to just in front of the posterior limit of the propleura; the narrow area anterior to this carina is shallowly channelled, pubescent and nearly smooth. Mesonotum short, a trifle wider than long (38: 33), strongly shining, the middle lobe finely but rather vaguely punctured, the punctures small, separated by about one diameter and somewhat obliquely placed; lateral lobes more or less impunctate; notaulices very deep, costate, meeting close to the posterior margin of the mesonotum, the surrounding surface at their juncture showing a few large punctiform

rugosities on the lateral lobes. Scutellum shining with small, sharp punctures separated by about twice their diameter; posteriorly with the merest trace of a margin; its anterior depression with 4 large pits. Propodeum with a clearly discrete posterior face, its dorsal surface short, extremely coarsely and irregularly reticulated, shining and bare except at sides; no trace of an areola; posterior face with 3 large, shining, bare areas; spiracles almost circular. Metapleura as coarsely reticulated as the dorsal surface of the propodeum, covered densely with silky, silvery-grey pubescence which somewhat obscures the underlying sculpture. Mesopleura with a deep, evenly and conspicuously costate furrow; mesosternum adjacent to the mesopleural furrow clearly punctate, but elsewhere becoming merely faintly roughened; medial, bare part of the mesopleura smooth, polished; pubescence of the mesopleura dense, silky, silvery-grey. *Legs*: hind coxa closely, finely and rather sharply punctate; hind femur (fig. 8); longer spur of the hind tibia half as long as hind tarsus 1; hind tarsus 1 a little more than $1\frac{1}{3}$ times as long as the remaining segments together (18:13); 3 a trifle shorter than 5 (5:6); all claws with a large, basal lobe. *Wings*: 2nd cubital cell with a long stalk (fig. 7); in the left wing the cell is so small as to be virtually absent; radius leaving stigma at slightly before middle; nervulus more or less interstitial; 1st abscissa of the medius of the hind wing very slightly shorter than the 2nd; basalis without a vein arising from it; venation of the hind wing pallid. *Abdomen*: short, oval, twice as long as its greatest width; tergite 1 as long as apically wide, large, with strong, lateral keels which almost reach the apical corners and with a short, even keel medially; the horizontal surface of this tergite is evenly and strongly striate, the interstices with the merest suggestion of rugosity; tergite (2+3) divided by a fine groove into its two separate segments; tergite 2 with a curved groove, the surface apical to which, especially laterally, is vaguely striated; tergite 3 with faint traces of a transverse impression. Ovipositor sheaths about as long as the abdomen plus propodeum.

Length: 6 mm. without ovipositor.

MALAYA: Kuala Lumpur, 1 ♀, the type (Ser. No. 02260), 13.vii.1938, bred from larva of *Earias fabia*, Stoll (Noctuidae).

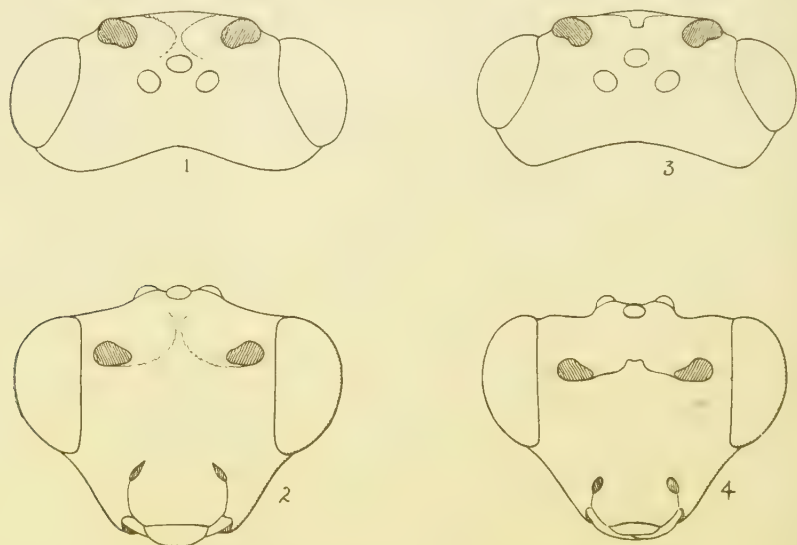


Fig. 1. *Microdus glyphodis*, sp. n., head (from above).
 " 2. " " " " (from in front)
 " 3. *Microdus fabiae*, sp. n., head (from above).
 " 4. " " " " (from in front)

The cocoon is brown, tough and of close texture. This is a distinctive-looking insect. I say this, however, with reservation, because if more material were available for study the characteristic features might prove to be no more than those of a group of species. Especially striking is the coarse sculpture on each side of the ocelli, and so is also the silvery-grey pubescence which clothes so much of the sides of the thorax.

***Microdus glyphodis*, sp. n.**

♀. Face and cheeks dull reddish brown with a yellowish streak against the eye-margin; upper part of the head and occiput blackish with a yellowish streak against the eye-margin on temples; thorax piceous with a reddish tint; abdomen black but about basal two-thirds of ventral surface ivory-white. Antennae piceous. Hind legs piceous throughout, their tarsal segments faintly paler at extreme apex; hind spurs whitish yellow; front and middle legs, apart from their coxae and the trochanters of the middle legs, which are darkened, more or less honey-yellow throughout. Palpi honey-yellow. Wings hyaline, but the front pair faintly brownish beyond middle of stigma.

Head a trifle wider than thorax across tegulae (9:8); seen from above sharply cut away behind the eyes (figs. 1 and 2). Face with normal vestiture of silvery pubescence, finely and indistinctly punctate, the small punctures separated by $1\frac{1}{2}$ to 2 diameters; towards the cheeks and on clypeus the punctures virtually disappear, the surface appearing dull and faintly roughened. Frons smooth, but not polished. Vertex smooth, polished and with the merest trace of punctures against the eye-margin near the antennal sockets. Antennae with 41 segments, rather slender, the 30th to the 40th segments nearly $1\frac{1}{2}$ times as long as wide. Ocelli arranged in a triangle with base much longer than sides; a tangent drawn at right angles to the longitudinal axis of the anterior ocellus just cuts the anterior margin of the posterior ocelli; ocell-ocular line about $2\frac{1}{2}$ times as long as the longer axis of a posterior ocellus. Segment 3 of the labial palpi very short, between $\frac{1}{4}$ and $\frac{1}{3}$ the length of the 4th. Labrum short, transverse. Frontal hollows not margined in front, the rounded anterior boundaries uniting medially to form a fairly sharp carina, which extends about halfway to anterior ocellus. *Thorax*: Pronotum with only a shallow unmargined impression on each side of the collar; sides of the pronotum anteriorly with a very poorly defined carina running roughly parallel to the anterior margin; the surface anterior to this carina and adjacent to it on posterior side, rugulose. Mesonotum narrow, longer than wide (19:16), rather strongly punctate, especially on middle lobe, the punctures somewhat oblique and separated by $1\frac{1}{2}$ to 2 diameters; the middle lobe shows a distinct median elevation which extends from the anterior margin backwards to just beyond middle; notaulices deep, indistinctly costate along bottom, meeting at a point distant from posterior margin by a length equal to two-thirds that of the scutellum. Scutellar shield coarsely rugose-punctate, posteriorly with a sharply defined, raised, transverse margin; the surface posterior to the ridge resembles a rugulose equilateral triangle; its anterior depression with two large, partly subdivided foveae. Propodeum with short dorsal and posterior faces; areola present, bounded by high lateral carinae and confluent with the corresponding area on the posterior face; on each side of the areola the surface is very coarsely reticulated; spiracles decidedly elongate. Metapleura with a large, median area of close, sharp punctation, the punctures separated by less than one diameter; pubescence of the metapleura fine and dense but not at all characteristic and not obscuring the sculpture of the surface beneath. Mesopleural furrow deep, somewhat irregularly foveate; disc smooth polished. Mesosternum closely, strongly punctate. *Legs*: hind coxa closely, rather strongly punctate, the punctures separated by rather less than one diameter; hind femur with similar punctation; in profile the hind femur is abruptly bent at base (fig. 6);

longer spur of the hind tibia a trifle less than half hind tarsus 1 (20:43); hind tarsus 1 fully $1\frac{1}{2}$ times as long as the remaining segments together. *Wings*: 2nd cubital cell of the fore wing with a slightly shorter stalk than in *fabiae* (cf. fig. 7), but otherwise venation hardly different; 1st abscissa of the medius of the hind wing a trifle shorter than the 2nd; basalis of the hind wing without a vein arising from it. *Abdomen* a little more than twice as long as wide; tergite 1 about $1\frac{1}{2}$ times as long as apically wide, with 2 strong lateral keels which more or less reach the apical corners and with a strong medial keel; horizontal surface strongly, evenly striate; about 7 ridges on each side, apart from the 3 keels; tergite (2+3) divided by a fine groove into its two separate segments; tergite 2 sculptured all over and with a feeble curved impression; the sculpture consists of somewhat obsolescent striate-rugosity; 3 smooth everywhere. Ovipositor sheaths as long as the abdomen plus propodeum.

Length: 5.5 mm. without ovipositor.

MALAYA: Johore, 1 ♀, the type (Ser. no. 5762), bred 26.i.1929, from *Margaronia* (*Glyphodes*) *coeruleiceps*, Hampson (Pylalidae).

A comparison of this species with another closely allied form from the same region (1 ♀, too damaged for description) suggests that it is chiefly characterised by the sculpture of the face, mesonotum and 2nd abdominal tergite.

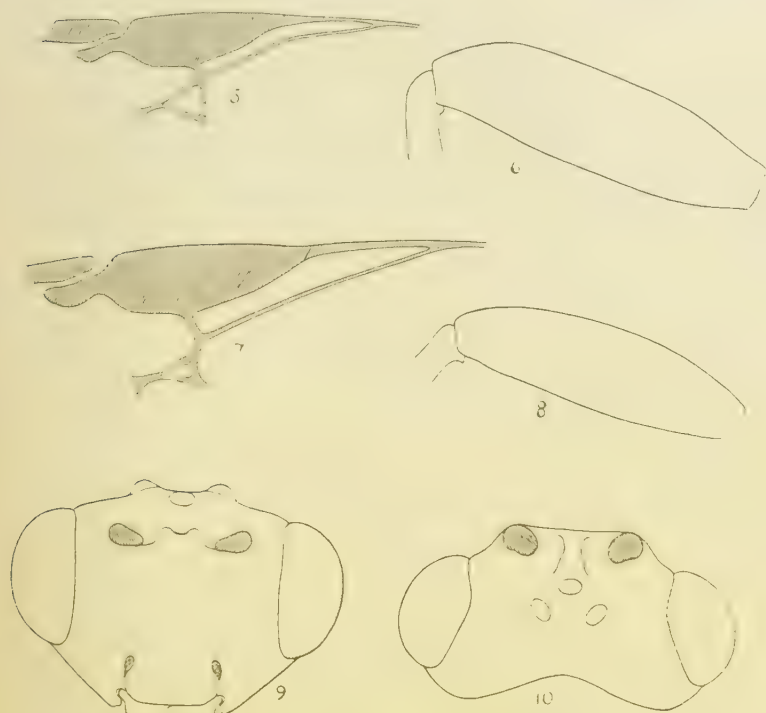
***Microdus leucotretae*, sp. n.**

♀. Entirely yellow-red, with the antennae and ovipositor sheaths black. Wings evenly smoky.

Head as wide as the thorax across the tegulae and, seen from above, more sharply cut away behind the eyes than in *bishopi*, sp. n. (cf. fig. 10), but otherwise as in that species. Face with short, more or less erect pubescence which, being erect, is not at all conspicuous, very shining, covered with small punctures which are separated from each other by 2-3 diameters; towards the cheeks, the punctures become smaller and tend to disappear. Clypeus virtually impunctate. Frons more or less smooth; frontal impressions separated by a short, simple, rather blunt keel. Vertex smooth, polished. Antenna broken, but probably with about 32 segments (the single male has 32); scape long, a trifle more than twice as long as its greatest width and a little longer than flagellum 1. Labrum short, transverse. Ocelli arranged in a triangle with base clearly longer than sides; a tangent drawn at right angles to the longitudinal axis of the anterior ocellus almost touches the posterior ocelli; ocell-ocular line a little less than twice the longer axis of a posterior ocellus (16:9). Segment 3 of the labial palpi very short, not longer than wide. *Thorax*: Pronotum with a fairly deep, unmarginated impression on each side of the collar. Mesonotum a trifle longer than greatest width (9:8) strongly shining, at first sight smooth and with only a trace of small, indistinct punctures; notaulices wanting. Scutellum strongly convex, shining, smooth, except for a few, small, very sparse punctures; posteriorly no trace of a transverse ridge; anterior furrow narrow, deep, nearly straight, at bottom only very feebly costate, its anterior slope very gradual. Propodeum, apart from its raised rugosities, somewhat convex in appearance; medially a subquadrate, reticulate or widely clathrate area is present; on each side of this area the surface is nearly smooth; spiracles small, circular; spiracular area not separated from the metapleura by even a trace of a carina. Metapleura shining, smooth, except for scattered, small punctures. Mesopleura shining, smooth except for small, remote punctures, which are absent over most of the middle part of the sclerite; furrow represented only by a short, more or less oval depression near middle coxa. *Legs*: hind coxa and hind femur with small, fairly sharp punctures, separated by 2-3 diameters; longer spur of the hind tibia a little less than half the basal segment of the hind tarsus (15:33); hind tibia with a cluster of about 20 stout spines

on inner side near apex; segment 1 of the hind tarsus as long as the following segments together; claws with a large basal lobe. *Wings*: 2nd cubital cell with a short stalk as in *bishopi*, sp. n., but the radial cell less narrow, the radius hardly curved (*cf.* fig. 5); 1st abscissa of the medius of the hind wing about three-quarters as long as the 2nd; basalis with a spurious vein arising from above middle. *Abdomen* fully $2\frac{1}{2}$ times as long as wide; tergite 1 large, as long as apically wide; its sculpture indefinite and obsolescent; a few large, puncture-like impressions medially in *type*, but hardly present in *paratype*, and towards apical corners traces of striation; its lateral keels fade out at middle; tergite (2+3) with a completely differentiated lateral margin extending from base to apex, finely striated almost to apex, marked by a fine, transverse furrow at middle, which probably corresponds to the division between the morphologically separate 2nd and 3rd tergites; tergite 2 with a similar furrow and tergite 3 with a furrow which is less clearly impressed than the other two; the three furrows are roughly equidistant from each other; following tergites smooth and shining. Ovipositor sheaths as long as the abdomen plus thorax.

Length: 5 mm. without ovipositor.



- Fig. 5. *Microdus bishopi*, sp. n., part of fore wing.
 " 6. *Microdus glyphodis*, sp. n., right femur (lateral).
 " 7. *Microdus fabiae*, sp. n., part of fore wing.
 " 8. " " right femur (lateral).
 " 9. *Microdus bishopi*, sp. n., head (from in front).
 " 10. " " (from above).

♂. Like the female, except that abdominal tergites beyond 4 are black. Antenna with 32 segments. The furrow on tergite 3 is more deeply impressed than in the female and is almost as strong as the other two.

Length: 5 mm.

S. RHODESIA: Mazoe, 1 ♀, the type, 20.i.1932; 1 ♀, ii.1932; 1 ♂, 13.vi.1931; all bred from the "false codling moth," *Argyroploce leucotreta*, Meyrick, on *Pseudolachnostylis maprouneaeifolia* (Euphorbiaceae) (W. K. Ford).

Lacking notaulices, this species is by no means a typical *Microdus*, but it is certainly best placed provisionally within this genus. I know of no species to which it appears to be closely allied.

***Microdus bishopi*, sp. n.**

♀. Entirely red-yellow, except as follows:—Antennae black; extreme apex of the hind tibiae brown; basal segment of the hind tarsi pale at base; infuscated apically but not at extreme apex; following segments of the hind tarsi showing a variable amount of infuscation, but the apex of the segments is always paler. Wings faintly darkened.

Head a trifle wider than the thorax across the tegulae (16:15); seen from above, not very sharply cut away behind the eyes (figs. 9, 10). Face with fine yellowish pubescence which appears to be absent over the middle part, the hairs here being so fine as to be hardly visible; extremely finely and not very sharply punctate, the punctures, especially towards the eye and cheeks, apparently just large enough to emit a hair. Frons with a trace of punctation towards the eye-margin; frontal impressions separated from each other by a weakly bituberculate elevation (fig. 9). Vertex smooth, except for the minute punctures from which the hairs arise. Antenna with 35-37 segments (6 ♀♀); scape long, almost twice as long as its greatest width, and a little shorter than flagellum 1 (10:13); flagellum rather slender, the more apical segments clearly longer than wide. Labrum short, transverse. Ocelli arranged in a triangle with base considerably longer than sides; a tangent drawn at right angles to the longitudinal axis of the median ocellus almost touches the posterior ocelli; ocell-ocular line nearly twice as long as the longer axis of a posterior ocellus (9:5). Segment 3 of the labial palpi very short, inconspicuous in the dried insect, only about one-quarter the length of the 4th segment. *Thorax*: Pronotum with a shallow unmarginated impression on each side of collar; this impression separated from the side of the pronotum by a short keel. Mesonotum longer than wide (43:37), shining, punctate, the punctures very small, separated by 3-4 diameters; notaulices distinct throughout, costate, becoming a little wider and more shallow posteriorly; they meet at a point distant from the foveae of the scutellum equal to about the length of the scutellar shield itself. Scutellum shining, weakly punctate, posteriorly without a trace of a transverse keel, its anterior depression divided by a single keel into two large, more or less circular hollows. Propodeum rugose-reticulate, but the broken keels defining the basic areas not much emphasised; areola weakly indicated; spiracles more or less circular; spiracular area separated from the metapleura by a well-defined but irregular ridge. Metapleura punctate, but less distinctly posteriorly. Mesopleura and mesosternum finely and rather indistinctly punctate, the punctures separated by about 3-4 diameters; mesopleural furrow deep, costate, not extending beyond middle. *Legs*: hind coxa with only extremely fine, setiferous punctures and at first sight appearing impunctate; hind femur much more strongly punctate, the punctures larger and separated by less than 2 diameters; longer spur of the hind tibia half the length of the basal segment of the hind tarsus; inner side of the hind tibia at apex with a cluster of about 14 stout spines; hind tarsus 1 as long as the remaining segments together; claws with a large basal lobe. *Wings*: 2nd cubital cell large, almost in the form of an equilateral triangle, not or hardly stalked

(fig. 5) ; 1st abscissa of the medius of the hind wing as long as the 2nd ; radius of hind wing running out to apical corner of wing, the radial cell hence more or less narrowly acuminate at apex ; basalis with a well marked spurious vein just above middle. *Abdomen* about 3 times as long as its greatest width ; tergite 1 rather narrow, $1\frac{1}{4}$ times as long as its apical width, finely, closely, smoothly striated ; tergite (2-3) with a fine groove separating its two component parts ; tergite 2 with a curved impression which has a few weak, transverse striae, the part anterior to the impression a little convex ; abdomen otherwise smooth. Ovipositor sheaths about as long as the thorax plus abdomen.

Length : 4.0-4.5 mm., without ovipositor.

♂. Differs from the female in having the body frequently marked with black as follows :—Head above with a large, blackish patch which embraces the ocellar region and spreads over the occipital region to as far as the neck ; lobes of the mesonotum usually blackened or embrowned in front ; tergites beyond 4 darkened. Size on the whole a little greater than in the female, some males reaching 5 mm.

Abdomen sometimes with more rugosity on tergite (2-3) ; the slight convexity of tergite 2 anterior to the impression sometimes with striations spreading on to it from the impression itself ; in such cases the surface of tergite 2 posterior to the impression also shows vague rugosity ; more often the entire surface of tergite 2 is smooth.

CAPE PROVINCE : Martindale, 7 ♀♀, one the type, 9 ♂♂, bred iv.1938 from the "false codling moth," *Argyroploce leucotrcta*, Meyrick, on *Citrus* (H. J. Bishop).

This species is extremely closely allied to *Microdus tautirae*, Cheesman, from the Society Islands, and I have been puzzled as to whether the differences between the two forms might not be merely racial. Nevertheless, I have since decided that it would be better to regard them as specifically distinct until more evidence to the contrary can be brought forward. A comparison follows.

***Microdus tautirae*, Cheesman.**

Microdus tautirae, Cheesman, 1928, Ann. Mag. N.H., (10) 1, p. 186, ♀.

♀. Tergite 4 with a dark brownish patch. Notaulices represented by more or less smooth impressions. Anterior depression of the scutellum narrower, with three strong ridges and a number of weaker ones.

SOCIETY IS. : Tahiti, Tautira, Valley Vaitepiha, 4 ♀♀, viii.1925 (L. E. Cheesman).

***Microdus aciculatus*, Brues (new combination).**

Bassus (*Microdus*) *aciculatus*, Brues, 1926, Proc. Amer. Acad. Arts Sci. 61 (8) p. 285.

I mention this species because it belongs to the same group as *bishopi* and *tautirae* and its host is known. It is extremely closely allied to *bishopi* and differs from it as follows :—

♀. Slightly larger and more stoutly built. Wings markedly smoky. Frons between the antennal sockets with a single smooth hump. Antenna shorter, stouter, 29-30-segmented (4 ♀♀). Notaulices a little deeper. Radius of the hind wing towards apex running parallel with the edge of the wing.

♂. Much more black on the body than the ♀ of *bishopi* : head entirely black, except for some yellow around the mouth-opening, a yellowish postorbital margin and a thin yellow orbital margin on the frons. Mesonotum and scutellum entirely black. Pronotum nearly black. Mesopleura red-brownish or blackish, except along the posterior margin. Abdomen beyond and including apical half of tergite 2-3 nearly black.

TANGANYIKA TERRITORY: Morogoro, the type ♀, bred from pupa of *Earias* sp. (Noctuidae) (A. H. Ritchie). UGANDA: Kampala, both sexes bred from *Earias biplaga*, Wlk., and a single female bred from *Earias insulana*, Boisd.; this last-mentioned female has the hind tibiae yellow throughout.

Microdus species, not known to the writer, from the African and Oriental regions:—

1. *Microdus amboiensis*, Fullaway, 1919, J. Straits Br. Asiat. Soc., **80**, p. 56, ♂. Amboina.
2. *Microdus antefurcalis*, Szépligeti, 1914, Mitt. zool. Mus. Berl., **7**, p. 220, ♀. Africa.
3. *Microdus cancellatus*, Enderlein, 1918, Arch. Naturgesch., **84** (A 11), p. 201, ♂. Formosa.
4. *Microdus* (*Orgiloneurus*) *concolor*, Szépligeti, 1914, Mitt. zool. Mus. Berl., **7**, p. 219, ♀. Africa.
5. *Microdus costatus*, Enderlein, 1918, Arch. Naturgesch., **84** (A 11), p. 201, ♂♀. Sumatra.
6. *Microdus distinctus*, Fullaway, 1919, J. Straits Br. Asiat. Soc., **80**, p. 57, ♀. Amboina.
7. *Microdus fumipennis*, Cameron, 1899, Mem. Manchr. Lit. Phil. Soc., **43**, p. 96, ♀. India.
8. *Microdus* (*Orgiloneurus*) *longisetu*, Szépligeti, 1914, Mitt. zool. Mus. Berl., **7**, p. 219, ♀. Africa.
9. *Microdus matangensis*, Cameron, 1905, J. Straits Br. Asiat. Soc., **44**, p. 115, ♂. Sarawak.
10. *Microdus pallidum*, Kriechbaumer (*Brachyrhopalum*), 1894, Berl. ent. Z., **39**, p. 312, ♀. Natal.
11. *Microdus postfurcalis*, Szépligeti, 1914, Mitt. zool. Mus. Berl., **7**, p. 220, ♀. Africa.
12. *Microdus punctatosulcatus*, Enderlein, 1918, Arch. Naturgesch., **84** (A 11), p. 202, ♀. Sumatra.
13. *Microdus rudimentarius*, Enderlein, 1918, Arch. Naturgesch., **84** (A 11), p. 202, ♀. Formosa.
14. *Microdus triangularis*, Szépligeti, 1914, Mitt. zool. Mus. Berl., **7**, p. 219, ♂. Africa.
15. *Microdus tuberculatus*, Cameron, 1899, Mem. Manchr. Lit. Phil. Soc., **43**, p. 95, ♀. India.

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THE RECORDED DISTRIBUTION OF CERTAIN FLEAS.

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As time passes and knowledge accumulates, it becomes more and more difficult and tedious to know whether a certain insect has been recorded from a particular region or country. The present note is an attempt to save other people's time and to set down what is recorded about the geographical distribution of five species of flea, *Xenopsylla cheopis*, *astia* and *brasiliensis*, *Nosopsyllus* (*Ceratophyllus*) *fasciatus* and *Pulex irritans*.

It is necessary to make clear how the information was accumulated. After a preliminary survey of the literature had been made, we engaged Miss B. Benzian, B.Sc., to carry out the work under my direction. She searched the ordinary bibliographies, looked up nearly all references in the original, and followed such further references as were then found: there were a few papers which were not read in the original, either because there was no copy in London or because they were in Slavonic languages. An attempt was made to search the literature completely to the end of 1938. By the kindness of Dr. K. Jordan, F.R.S., Miss Benzian also examined many hundreds of tubes of specimens at Tring Museum and tabulated the results. The information obtained in these ways (including a certain amount of negative information that certain species had been looked for but not found) was recorded on slips and then transferred to a series of large-scale maps by countries and continents. The slips and these maps would make it easy to answer questions such as whether a particular flea has ever been recorded from a certain country and if so, from what places, when, and by whom. I take this opportunity for thanking Miss Benzian who carried out her part of the work in a very careful and uniform manner.



Fig. 1. Approximate recorded distribution of *Xenopsylla cheopis*, Roths.

My colleague, Mr. H. S. Leeson, took the large scale maps and reduced them to the 5 text-figures which are published herewith. In doing so it was necessary to use his personal judgment, in deciding whether there were enough records to justify showing an area in black or whether the records should be shown as isolated points. His figures are drawn on Boggs' projection, which appears to be excellent for showing the distribution of a terrestrial organism. It will be seen that the outlines of land areas are so arranged as to give very little distortion at least in the continents. Outline maps on this projection are published by Geographical Publications, Ltd.



Fig. 2. Approximate recorded distribution of *Xenopsylla astia*, Roths.

In surveying the literature we were struck by the number of records which are so vague as to be without value: there are for instance records of *Xenopsylla cheopis* from "Nigeria" and "Colombia," both of them large countries with a great variety of climate, surface features, etc. There are also many records which cannot be traced, some because they give nothing but the name of a village, others because many places have the same name; this is especially true of South America, where there is a tendency to name villages after saints. There are also particular difficulties in tracing names in the U.S.S.R.; this is partly due to the existence of different systems of transliteration (and one observes that some of the abstracting journals have no system), but also to the many new place names. Even after studying several large atlases and receiving much help from the staff of the Royal Geographical Society, Miss Benzian found it impossible to trace several hundred recorded localities. There are particular difficulties in mapping the distribution of *Nosopsyllus fasciatus* because many tropical records were made by simple-minded people who thought that any flea with a comb on the prothorax belonged to this species. As it seemed impossible to pick out the reliable records, I have based the text-figure (fig. 4) only on actual specimens in the Tring collection. The figure therefore represents something less than the truth, for we have doubtless rejected many

reliable records, especially from temperate America. Difficulties due to faulty identifications are probably much less in the other four species, though one must exercise caution with African, and especially West African, records of *Xenopsylla*. On the whole there are no great difficulties due to synonymy among the insects dealt with in this paper.



Fig. 3. Approximate recorded distribution of *Xenopsylla brasiliensis*, Roths.



Fig. 4. Approximate recorded distribution of *Nosopsyllus* (*Ceratophyllus*) *fasciatus*, Bosc., based only on actual specimens in the Tring collection, British Museum.

It is a matter of some interest to know the cost of such an enquiry as this. If one engages a person with some scientific knowledge and an ability to read several languages and if one's aim is thoroughness, the figure lies between £10 and £25 per species.



Fig. 5. Approximate recorded distribution of *Pulex irritans*, Linn.

TWO NEW METHODS OF TRAPPING THE CACAO MOTH (*EPHESTIA CAUTELLA*).

By F. D. GOLDING, M.A., F.R.E.S.

The so-called Cacao Moth of West Africa is the Fig Moth, *Ephestia cautella*, Wlk. ; *E. elutella* has not been recorded from Nigeria or, to the writer's knowledge, from the Gold Coast.

Ephestia infestation is serious only in those seasons in which cacao is stored locally for long periods, on account of marketing considerations or other factors. At the present time war conditions have resulted in large quantities of cacao being stored locally whilst awaiting shipment ; *Ephestia* has been numerous in some stores in several localities.

The principal object of this paper is to describe two new methods of trapping *Ephestia* adults in stores, both of which have given excellent results. Neither method was devised by the writer, whose role has been to carry out a series of experiments with the object of perfecting the methods and of gaining information about the habits of the moths.

It should be stressed that the methods described of trapping adult *Ephestia* are intended to supplement, and not to replace, the routine measures of control, which are widely employed in Nigerian cacao stores and have been recommended by the Produce Inspection branch. These measures are as follows :—Scrupulous cleanliness, frequent whitewashing of walls, brushing the outside bags to destroy larvae and pupae, stacking of bags on scantling, and leaving an alleyway between the bags and the outside walls of stores. A very satisfactory degree of control can be obtained by the employment of these measures in conjunction with até strands.

The Até Strand Method.

Mr. Highmoor, of Cocoa Manufacturers Ltd., noticed that *Ephestia* adults settled in numbers on some packing threads which a labourer had happened to throw over a beam in a store. Mr. J. K. B. Lee, of the same firm, then obtained a native bird-lime known as "até" (the latex of a vine, probably *Carpodinus* sp., coagulated with lime-juice) which he mixed with half the quantity of palm oil, heated and applied to broom strands. The treated strands were suspended from a horizontal string tied along an alleyway in a cacao store. Mr. Lee noticed that, although many moths were caught, a small proportion succeeded in escaping from the adhesive. According to one of the writer's African assistants, who had used até bird-lime in his youth, the coagulated latex was thoroughly kneaded with palm oil and was then ready for use. A test was carried out with até prepared in this way (without being heated) and the resultant mixture was found to be unsuitable for application to broom strands ; it was difficult to apply and not as viscous as the heated mixture.

Mr. J. H. Mackay, of the Forestry Department, obtained a supply of uncoagulated até latex, and the writer carried out a series of experiments with both coagulated and uncoagulated latex and with various other adhesive substances. The results of these experiments and of some observations on the habits of adult *E. cautella* are described below.

Selection of Resting Sites.

The broom strands originally used by Mr. Lee are known to the Yoruba as "owo" or "igbale," they are the midribs of leaflets of the oil palm (*Elais guineensis*) and

are about 2 feet in length. Subsequently Mr. Lee utilised the midribs of the wine palm (*Raphia sudanica*) on account of their greater length.

The writer suspended two pieces of twine in an alleyway between stacks of cacao bags in a store and attached one of each of the following articles to each piece of twine :—"Owo" broom strand (1.5 mm.), thin twine (1 mm.), thick twine (3 mm.), good quality packing thread (3 mm.), medium quality packing thread (3 mm.), thin wire (1 mm.), thick wire (5 mm.), smooth branch of a tree (6 mm.) and smooth sliver of wood (6 mm.). The approximate diameter of each article is shown in brackets ; the length of the thin wire was 15 ins. and of the remaining articles about 24 ins.

The number of moths resting on each object was determined on the mornings of 23rd, 26th and 28th March, and the results are shown in the following table :—

TABLE I.

Object in duplicate				No. of moths on			
				23rd March	26th March	28th March	Total
Broom strand	...	...	...	7	34	20	61
Thin twine	...	...	...	16	30	24	70
Thick twine	...	...	...	4	11	17	32
G.Q. packing thread	...	...	...	9	23	19	51
M.Q. packing thread	...	...	...	17	22	19	58
Thin wire	...	...	...	0	9	7	16
Thick wire	...	...	...	5	3	1	9
Tree branch	...	...	...	2	4	7	13
Wood sliver	...	...	...	13	7	5	25

The last four objects, on which the smallest numbers of moths rested, had one characteristic in common, viz., smoothness. It seems probable that the factor of attraction is a good foothold ; broom strands have many surface irregularities, some of them being due to the presence of small proximal portions of the leaf lamina still attached to the midrib. The packing threads offered good footholds, but both the thin and thick twine used were comparatively smooth. When at rest the main axis of the cacao moth's body is at an angle of about 15 degrees from the main axis of the object on which it is resting, the extremities of the folded wings are applied against the supporting object. Observation showed that the narrow diameter of the thin twine enabled the moths to find secure resting places on it ; the thin wire, although of the same diameter, did not give an adequate foothold. If a strip of sacking, about two inches in width, was suspended most of the moths settled on the small pieces of thread projecting from the frayed edges. If thin wire was painted and sawdust particles were attached to it (whilst the paint was still wet) more moths would settle on it than on painted wire without sawdust adhering to it. In addition, Mr. Lee found that moths were attracted to wooden slivers if the edges were chipped to form small projections.

Threads and twine are difficult to handle after they have been treated with an adhesive and broom strands are more suitable for the purpose required.

A piece of thin twine was suspended from a beam, 10 ft. above ground-level, to the floor of a store. The next morning it was found that moths were evenly distributed over the uppermost 7 ft. of twine, but there were very few moths resting at a height of less than 3 ft. above ground-level. Corroboration of this observation was obtained by suspending fly-papers at different levels; papers hung with their tops 10 ft. above ground-level caught about $1\frac{2}{3}$ times as many moths as those with their tops $3\frac{1}{2}$ ft. above the floor.

Distribution of Moths in the Store.

During the course of experimental work in three corrugated iron stores, each 100 ft. long by 25 ft. wide, it was observed that the moth population was markedly greater in the eastern half of each store than in the western half. The three stores were parallel to one another with their main axes running almost due east to west. In late April, maximum shade temperature was recorded, at a height of 6 ft. 3 ins. above the floor, at both ends of one of these stores. It was found that the maximum shade temperature was from 3 to $4\frac{1}{2}^{\circ}$ Fahr. higher at the western end than at the eastern end. There were large sliding doors at each end of the store which were opened at about 9 a.m. and closed at about 4 p.m. It seems probable that the factor responsible for the greater concentration of moths in the eastern halves of the stores was the cooler conditions prevailing there rather than a negative phototropic response to direct sunlight entering the western doors in the late afternoon. The maximum shade temperature at the western end of the store was 102° Fahr. in late April.

This observation proved to be of considerable practical importance, both in the carrying out of experiments in the stores and in the final control work designed to reduce the *Ephestia* adult population to negligible proportions.

Experiments with Adhesives.

Before Mr. Lee devised the até strand method, the writer had carried out a long series of experiments with the object of discovering adhesives suitable for the local manufacture of fly-papers. Some of these adhesives proved to be satisfactory for use on fly-papers, but none of them was found to be suitable for use on broom strands. These adhesives consisted of varying proportions of imported resin (rosin or colophony) heated with one of the following substances:—castor oil, palm oil, linseed oil or shea butter (obtained from *Butyrospermum Parkii*).

Experiments proved that one até broom strand was capable of catching about three times as many moths in one night as a fly-paper. The only attractants available for incorporation with the adhesives used on fly-papers were amyl acetate and fermented fruit juices. Even if a more efficient attractant could be found there are numerous objections to the employment of fly-papers against the cacao moth. Large numbers of papers would have to be used in each store and the cost of treatment would be high; also it is undesirable to use paper for this purpose in war time. Fly-papers are troublesome to make, and it was found that some of the firms had difficulty in preparing the adhesives recommended, although none was experienced in the laboratory. Lastly, the writer was unable to find a substitute for rosin from among the numerous local resins kindly supplied to him by Mr. Mackay.

There is no object in giving in detail the results of the various experiments carried out with different adhesives in a number of cacao stores in the Ibadan district. In heavily infested stores as many as 111 moths have been caught on one Raphia strand, 2 ft. 9 ins. long, in one night, and catches of from 60 to 80 moths per strand were frequent.

The best type of adhesive was found to be a mixture of three parts coagulated até to one part of either shea butter or palm oil. This adhesive retains its viscosity

for several weeks and, as an index to the strength of the até-shea butter mixture, it may be mentioned that a rat was trapped in one store in Ibadan and a bat in another store!

Method of Making Até-Shea Butter Adhesive.

Mr. Mackay arranged for African contractors to obtain supplies of até from a forest reserve near Ibadan; these men charge 10s. a gallon for uncoagulated latex and 1s. a lb. for coagulated até. If kept for long periods, até tends to coagulate naturally, but it is immaterial whether coagulation has taken place naturally or has been induced by artificial means.

If uncoagulated latex is obtained, lime-juice is added until maximum coagulation has occurred; there is always a milky uncoagulated residue. Stirring should be carried out during the process. The coagulated até is then kneaded thoroughly under water to remove excess lime-juice and impurities. Three parts by weight of coagulated até and one part of shea butter (or palm oil) are placed in a saucepan over a slow fire (preferably charcoal) and are stirred vigorously and continuously until the two ingredients become thoroughly incorporated (the lump of até will then have melted completely). The mixture is allowed to cool and is then applied to the broom strands. A quantity of the adhesive is taken in the fingers and the strand is twisted by the other hand during application; in effect, the adhesive is wound on the strand.

One man can prepare about 200 to 300 strands in a day and 500 strands are required to treat a store 100 ft. long by 25 ft. wide.

The strands are attached at about one-foot intervals to long pieces of twine by means of clove hitches or simple overhand knots. The twine is then suspended, at a height of about 10 ft. above floor-level, in the various alleyways between the stacks of cacao bags. For a store 100 ft. long by 25 ft. wide about 450 ft. of twine will be required; the cheapest type of twine available in Nigeria is that sold for the manufacture of fishing nets (over 500 yards can be obtained for 2s. 6d.).

As stated above, coagulated até costs 1s. a lb. in the Ibadan district. Shea butter costs 4½d. a lb. locally and Raphia brooms, each containing about 250 strands, cost 1d. each. About 6 lb. of coagulated até and 2 lb. of shea butter are required to treat 500 broom strands (3 ft. 6 ins. to 4 ft. in length), so that the cost of treating a store 100 ft. long by 25 ft. wide is about 6s. 11d., exclusive of the cost of twine and labour.

Até Substitutes.

Capt. J. R. Mackie, Director of Agriculture, suggested to the writer that it might be possible to utilise Para rubber (*Hevea brasiliensis*) as a substitute for até. Rubber latex contains about 2 per cent. of resin, while até contains about 60 to 80 per cent. resin. It was found that a good adhesive could be prepared by mixing one part of Hevea latex with four parts of shea butter, and that a mixture of one part Hevea latex, three parts até and five parts shea butter was as effective as the standard coagulated até-shea mixture described above. The cost of the 1:3:5 mixture was about 75 per cent. of that of the standard adhesive, but it was found to be effective only in corrugated iron stores during hot weather. In cool stores the mixture hardens rapidly and, although it becomes viscous again on being exposed to the sun for about five minutes, it cannot be recommended for general use. Maximum shade temperatures were recorded in two cacao stores in Ibadan; in the first store, in which the 1:3:5 mixture was giving excellent results, the maximum temperature varied from 98 to 99 Fahr. in late May. During the same period the maximum temperature ranged from 90 to 93 Fahr. in the second store, in which the mixture had hardened and was failing to catch any moths.

Only one proprietary adhesive was available. The high temperature in the stores resulted in this adhesive becoming too thin, and it compared very unfavourably with the standard até mixture. There seems to be little doubt that one or other of the proprietary adhesives used for tree-banding would prove to be highly effective for catching *Ephestia* adults in stores and warehouses in England, and it is hoped to obtain one which will give satisfactory results under the temperature conditions prevailing in stores in Nigeria.

The Carbolic Soap Method.

Some years ago, officers of the Produce Inspection section of the Nigerian Agricultural Department carried out experiments with moth traps consisting of various liquids placed in bowls or dishes. A number of the liquids recommended by Noyes¹ and Cotterell² were tested against gari (a floury substance obtained from cassava roots) and water. Gari and water was found to give the best results and, for several years, has been used by the various firms as the standard medium for dish traps.

In March 1940, it was discovered in the Port Harcourt area that carbolic soap solution is a most effective medium for use in dish traps; the name of the person responsible for this discovery is unknown to the writer. On hearing of this matter, a preliminary test was made, in a heavily infested store, with three dishes containing, respectively, a strong solution of carbolic soap in water, water alone, and fermented banana juice. The dishes were examined after 48 hours and were found to contain the following number of Cacao moths: soap solution 423, water 69, and banana juice 123. Owing to the large amount of soap used the solution had become jellied. A further test was made in which dishes containing carbolic soap solution, hard white curd soap solution, and gari and water were employed; the results are shown in Table II.

TABLE II.
Dishes placed in store on 1st April.

	Carbolic soap		White soap		Gari and water			
	No. 1	No. 2	No. 1	No. 2	No. 1	No. 2	No. 3	No. 4
No. of moths trapped in two days ending on 3rd April ...	230	108	175	104	21	19	46	26
5th April... ..	136	82	128	67	22	37	20	30
Total in 4 days ...	366	190	303	171	43	56	66	56

Further experiments showed that various locally-made native soaps were as effective as carbolic soap, and that there was little difference between the number of moths caught by solutions made with two brands of carbolic soap. One advantage of soap solution over gari and water is that mosquitoes do not breed in it.

Strength of Soap Solution.

A series of experiments was made with the object of determining the optimum quantity of soap to use in one litre of water; the type of dishes utilised required one litre of solution to fill them. The first test was made with soap solutions of 1:1,000, 2:1,000 and 3:1,000; the number of moths trapped in three days was 85, 175 and 190 respectively. There were 22 moths in the control dish, which contained

one litre of water. A second test was carried out with soap solutions of 3 : 1,000, 6 : 1,000, 8 : 1,000 and 10 : 1,000 ; the number of moths trapped in three days was 211, 260, 192 and 234 respectively.

Jellying of Soap Solutions.

It was found that if 12.5 or more gms. of soap were dissolved in one litre of water, jellying occurred. The writer found that soap jellies caught more moths than soap solutions ; but Mr. R. M. Steven, in a large-scale experiment at Abeokuta, trapped nearly five times as many moths in solutions as in jellies. Moths caught in solutions sink to the bottom of the dish, whilst those caught in jellies remain on the surface, it would be a tedious process removing moths from jellies every two or three days. For practical purposes solutions are preferable to jellies, and the strength finally recommended was from 1 to 2 oz. of soap per gallon of water.

Kerosene Soap Emulsions.

Owing to a misunderstanding, Mr. Marshall, of the United Africa Co., used considerably more soap (7 oz. per gal. water) than was recommended ; on finding that jellying had occurred, he melted the soap jelly by heating and emulsified it with kerosene. He found that the emulsion was a very effective trapping medium and continued to use it in the stores under his charge during the period when the writer was perfecting the até strand method. A small scale test carried out by the writer indicated that kerosene soap emulsions were more effective than soap solutions ; but work on dish traps was discontinued when the até strand method had been perfected. It was found that one strand was capable of catching about $1\frac{1}{2}$ times as many moths in a night as one dish containing soap solution. For less than 8s., 500 até strands can be placed in a store, whereas considerations of space strictly limit the number of dish traps that can be used, quite apart from the heavy initial outlay required for the purchase of the dishes. Heavily infested stores have been almost completely rid of moths in two or three nights by means of até strands ; but in the writer's experience, dish-trapping is incapable of achieving this almost complete eradication. The firms in Ibadan which are employing the até strand method have now abandoned the use of dish traps.

Factors attracting *Ephestia* Adults to Traps.

As far as can be ascertained, *Ephestia* moths are not attracted to até strands by odours emanating from the adhesive substances employed. They will settle in large numbers on untreated strands or on twine of various kinds. It seems probable that the attraction is physical in character ; after the night's activity, the moths seek resting places for the day and prefer to rest on objects to which they can cling securely rather than on the flat surfaces of bags or beams. The writer believes that the degree of viscosity of the adhesive is the important factor in trapping with broom strands.

With regard to dish traps, Noyes¹ states that " It was proved that it is the smell which attracts the moths, in that they are caught in far greater numbers by the vinegar and fermenting fruit syrup mixtures, than by the plain water or flour and water mixtures." In the writer's opinion, this proof is not entirely conclusive. Moths caught in water float on the surfaces, but, as stated above, those in soap solutions sink to the bottom of the dish ; it is not improbable that the reduction in surface tension, due to the inclusion of soap, plays an important part in making soap solutions effective.

Stored Products attacked by *E. cautella* Larvae in Nigeria.

In addition to cacao, *E. cautella* larvae attack stored ground-nuts and, occasionally, maize. Adult specimens have been received from stores containing palm kernels,

in the Eastern Provinces, but the writer has never been able to establish definitely that the larvae attack this product, nor has he ever seen kernels infested by *Ephestia* larvae in the Western Provinces.

Turner³ gives data regarding the ground-nut industry of Northern Nigeria; from 1932 to 1938, between 180,136 and 325,929 tons of decorticated nuts were exported annually. The bulk of the crop is carried by rail between October and May; during the same period the bulk of the main crop cacao is also on its way to the coast for shipment. In the 1933-34 export season there were several occasions on which railway wagons, sent to Ibadan to load cacao, had to be rejected on account of the presence of cacao moths and beetles. It was suspected, though never definitely proved, that the wagons had become infested as a result of their being used for the transport of ground-nuts. In September 1934, Mr. P. H. Soper, of Cocoa Manufacturers Ltd., observed that *Ephestia* adults were common in export stores containing ground-nuts at Apapa and, in September 1936, Mr. A. H. Young, Chief Inspector of Produce, reported a heavy infestation on ground-nuts at Kano. Although the bulk of the ground-nut crop is railed before June, occasional consignments are still received at Apapa up to the end of October; soon after that the new crop railments begin. The infested nuts seen by Messrs. Soper and Young were old crop and must have been harvested some 10 to 11 months previously.

On 3rd October 1939, the writer visited the export stores at Apapa and examined some old crop (1938) ground-nuts. They were found to be heavily infested with *Tribolium castaneum*, Hbst., and several *Ephestia* adults were seen. Samples taken from the bags were found to contain cacao moth larvae. A second visit was paid to these stores on 6th December, when they were almost completely filled with bags containing several thousand tons of new crop nuts; no sign of insect infestation could be found. On 8th February 1940, Mr. J. Watling, Senior Inspector of Produce, visited the stores at the writer's request and found that the ground-nuts in two bays of one store, which had been lying there for some weeks, were heavily infested by *Tribolium*; *Ephestia* adults were seen in each of the four stores.

One of the writer's assistants examined stored old crop nuts at Kano on 4th October 1939, and found them to be heavily infested by *Tribolium*; whilst in March 1940, Mr. H. G. Pudney, Inspector of Produce, reported that he had found a few *Ephestia* larvae in new crop nuts in the same locality and also that *Ephestia* and *Tribolium* adults were common in all stores.

There seems to be no doubt that if it were possible to restrict the export period for ground-nuts to seven months, instead of twelve, there would be a marked reduction in the ravages of insect pests.

Considerable divergence of opinion exists as to the respective degree of attraction of ground-nuts and cacao for *E. cautella*. The writer carried out an experiment in which 20 moths were placed in a jar containing both broken cacao beans and broken ground-nuts. Sixteen days later it was found that there was a very heavy larval infestation of both products; but the ground-nuts had suffered more severely than the cacao beans—possibly on account of the low moisture content of the latter at the time of the experiment, viz. 5.8 per cent.

A similar experiment was made with broken cacao beans and broken palm kernels; larvae attacked the cacao, but no damage was done to the kernels.

It was found that *Ephestia* larvae are capable of attacking sound ground-nuts, entry being made at the end of the nut.

Beetle Infestation in Cacao Stores.

During the preliminary work on fly-papers, in early February, vast numbers of the minute Cucujid beetle, *Ahasuerus advena*, Waltl, were present in some of the cacao stores. The beetles did not appear to be attacking cacao, and when adult

beetles were placed in jars with cacao beans they died without feeding or breeding. The cacao was in excellent condition, and there was no evidence of mould to attract the beetles. Many beetles were caught on fly-papers and in dishes containing gari and water; hundreds of beetles sheltered on the floor underneath the dishes. Within a few weeks the stores were almost entirely free from *A. advena*, and it seems possible that the arid atmospheric conditions of January were primarily responsible for their presence in the stores.

At the same time, a few adults of *Araecerus fasciculatus*, de Geer, were taken on fly-papers, but there was no evidence of an increase in numbers up to the time of writing (early June 1940). The moisture content of beans in one store was determined by Mr. A. O. Longe and found to be 5.7 to 5.8 per cent. Cotterell² has shown that if the water content of cacao beans is less than 8 per cent. they suffer little damage from *Araecerus*.

In early April, insect damage in one store (that containing cacao with a moisture content of 5.7 to 5.8 per cent.) had risen above the limits permitted by the Produce Regulations. Examination by the writer showed that the insect responsible for the damage was *Lasioderma serricorne*, F. In the past, there were a few instances of this tobacco beetle seriously infesting cacao, but the quantity affected was inconsiderable. In the present storage season, *Lasioderma* has been abundant in several stores in the Ibadan district and in Ijebu-Ode. *Lasioderma* adults were frequently trapped on fly-papers and, in common with the other species of beetles, were most abundant on papers hung at low levels, i.e. with their tops less than 8 ft. above ground-level. The writer recommended an adhesive, consisting of three parts rosin and one part of shea butter (heated together), for testing on fly-papers against *Lasioderma* in the Ijebu-Ode area; Mr. Ajayi, who carried out the tests, reported that two papers caught 658 beetles in a fortnight. Até strands also catch tobacco beetles, but the writer considers that fly-papers are more effective against beetles. *Lasioderma* adults are positively phototropic, whilst *Ephestia* avoids light; when trapping is used against the tobacco beetle, the best results are obtained when the papers are placed in a light situation.

Summary.

1. Two new methods of trapping *Ephestia cautella* adults in cacao stores are described.

2. In the first method, devised by Mr. J. K. B. Lee, broom strands are treated with an adhesive and then suspended from twine in the alleyways between the stacked bags. Mr. Lee heated two parts of coagulated até (derived from the latex of a species of *Carpodinus*) with one part of palm oil and applied the adhesive, while hot, to the strands. The writer carried out a long series of experiments with various adhesives, with the object of perfecting the broom strand method, and finally came to the conclusion that the best adhesives for general use were those made by heating three parts of coagulated até with one part of either shea butter or palm oil. The adhesive should be allowed to cool before applying it to the strands.

3. It was discovered, in the Port Harcourt area, that carbolic soap solution is an excellent medium for use in dish traps. The writer found that carbolic soap solution caught many more moths than the standard medium used in Nigeria. Several other types of soap, both imported and locally made, proved to be nearly as effective as carbolic soap. The best strength for carbolic soap solution was found to be from 1 to 2 oz. soap per gal. water.

4. The infestation of ground-nuts by *Ephestia* is discussed, and the opinion is expressed that this could be considerably reduced if it were found practicable to reduce the length of the export season from 12 to 7 months.

5. During the dry season storage period (October to May), the tobacco beetle, *Lasioderma serricorne*, was abundant in some stores and caused considerable damage to cacao beans with a moisture content as low as 5.7 per cent.

Acknowledgments.

The writer wishes to express his deep appreciation of Mr. J. K. B. Lee's valuable co-operation in the research work, and to express his gratitude to Mr. J. H. Mackay for providing him with various latices, resins and gums, and for arranging for the large scale supply of até by contract. Valuable help, in various forms, was received from the following members of cacao-buying firms: Messrs. Dyer, Highmoor, Evans, Pickmere and Marshall, and also from Messrs. Watling, Hardwick, Pound and Warner, of the Produce Inspection branch of the Agricultural Department. Mention should be made of the good work done by Mr. F. O. Iwenjora, to whose lot fell the task of preparing the various adhesives required for trial.

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APPENDIX.

It may be of value to place on record a list of some of the various substances and mixtures which were tested by the writer during his experimental work on adhesives.

(1). *Fly-papers.*

(a) None of the local substances tested was found to be a suitable substitute for imported rosin; these were resins or gums from the following trees: *Daniellia Ogea*, *Canarium Schweinfurthii*, *Sterculia Tragacantha*, *Gossweilerodendron balsamiferum*, *Copaifera Ehie* and *Acacia* spp.

(b) The adhesives which gave the best results (as regards the retention of viscosity and moth catches) were the following: 2 pts. rosin, 1 pt. castor oil; 3 pts. rosin, 1 pt. shea butter; 3 pts. rosin, 1 pt. palm oil; 6 pts. rosin, 1 pt. linseed oil, 1 pt. castor oil; 6 pts. rosin, 1 pt. linseed oil, 1 pt. palm oil. The oils were heated for 3 mins. before adding the powdered rosin; heating was continued with vigorous and continuous stirring until the two substances were thoroughly mixed. It was seldom that a fly-paper retained its viscosity for more than a fortnight, whereas até strands are effective for more than a month.

(2). *Broom strands.*

(a) All the adhesives mentioned in (1)(b) were found to be of no use for the treatment of broom strands.

(b) The latices of *Funtumia elastica* and *Ficus Thonningii* were useless. The latex of a vine, probably *Landolphia owariensis*, was useless alone, but when mixed with uncoagulated até in the following proportions: 1 pt. *Landolphia*, 3 pts. até, 5 pts. shea butter, gave an excellent adhesive for use in hot stores. Similar adhesives

suitable for use in hot stores, were as follows : 1 pt. *Hevea*, 3 pts. uncoagulated até, 5 pts. shea ; 1 *Hevea*, 4 shea ; 1 *Hevea*, 1 uncoagulated até, 2 shea ; 4 uncoagulated até, 1 shea.

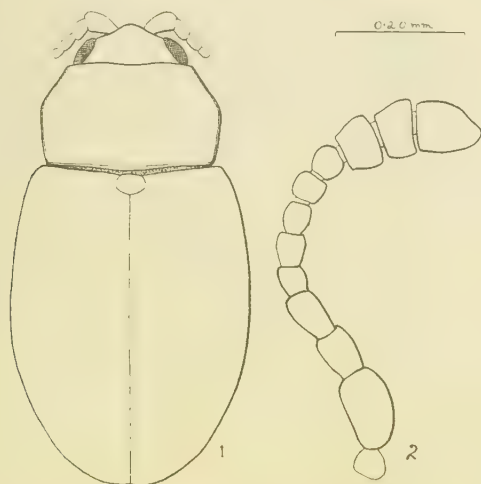
(c) A mixture of uncoagulated até and shea butter (4 : 1) gave better results than mixtures of uncoagulated até and either palm oil or ground-nut oil. On the other hand, coagulated até and palm oil (3 : 1) is equally as good as coagulated até and shea butter (3 : 1) over long periods of trapping ; it is not quite so viscous, but retains its viscosity longer.

A NEW *ATOMARIA* FROM MUSHROOM-BEDS IN SOUTH AFRICA
(COL., CRYPTOPHAGIDAE).

By H. E. HINTON, Ph.D.

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I have been asked by the Imperial Institute of Entomology to identify a beetle found in mushroom-beds in South Africa. This beetle proves to be a new species of *Atomaria*. The genus *Atomaria* consists of about 165 species chiefly confined to the holarctic region. One of these, *A. linearis*, Stephens, is sometimes a serious pest of sugar-beet and mangold, eating the leaves and roots. Other species, e.g. *A. nigripennis* (Kugelann) and *A. atricapilla*, Stephens, are found in houses, cellars and warehouses, where they probably feed on fungi.



Figs. 1 & 2. *Atomaria (Anchicera) psallioticola*, sp. n. : (1) dorsal view of whole insect ;
(2) antenna.

***Atomaria (Anchicera) psallioticola*, sp. n. (figs. 1 & 2).**

♂. Length, 1.6 mm.; breadth, 0.82 mm. Body broadly obovate; dorsal surface moderately densely clothed with fine, semi-erect, brownish or testaceous hairs which are about as long as third antennal segment. Cuticle strongly shining and moderately dark reddish-brown; legs brownish-testaceous. *Head* between antennae less than half as broad as length of first antennal segment; surface with round punctures slightly finer than facets of eyes and usually separated by less than one to one and a half diameters; surface between punctures smooth. Eyes large (0.13 mm. broad), nearly round, moderately convex, and separated by about one-third their diameter from base of antennae. Antenna (fig. 2) 11-segmented. *Pronotum* across broadest point, which is slightly but distinctly in front of middle, broader than long (0.63 : 0.46 mm.) and base broader than apex (0.57 : 0.41 mm.). Sides

rounded, feebly angulate opposite broadest point, and finely, completely margined; base very feebly rounded, scarcely noticeably sinuate on each side, and with a complete marginal line. Pronotum with middle two-thirds of base transversely impressed, this flat basal region without trace of carina (plica) at sides and at middle about three-fifths as long as scutellum; surface of disk with punctures deep, round, as coarse as to slightly coarser than facets of eyes, and separated by one-half to a little more than one diameter; near anterior angles with punctures slightly coarser and denser; surface between punctures smooth. *Elytra* more than twice as long as pronotum (1.15:0.46 mm.) and broadest between middle and basal two-fifths; sides evenly rounded to apex. Humeri moderately prominent but only feebly gibbous; surface shallowly depressed near base on each side before humerus. Surface on basal half of disk with punctures distinctly finer than those of pronotal disk, about as coarse as those of head, and separated by two to three diameters; towards apex punctures become much finer and sparser so that by apical third they are half as coarse as facets of eyes and are separated by four to seven diameters. Pubescence evenly distributed and rather equal, but slightly shorter on middle apical region. *Prosternum* with process parallel, about two-thirds as broad as front coxae, caudal margin truncate, and sides feebly, broadly raised; surface punctate like pronotum near apical angles. *Hypomera* punctate like sides of prosternum but very slightly more coarsely so. *Metasternum* with median longitudinal line narrow, shallow, and confined to caudal half; disk sculptured like middle of elytra; extreme sides and metasternal episterna more densely and nearly as coarsely punctate as base of elytra. Abdomen with middle of first sternite punctate like metasternal disk; sides of first sternite and all of other sternites distinctly more sparsely and finely punctate.

♀. Externally similar to male.

SOUTH AFRICA: Pretoria, x.1938, in mushroom bed.

Type: In the British Museum (Nat. Hist.); *paratypes*: 4, with same data as above.

5 *Comparative notes*: Only a single species of *Atomaria*, *A. (Anchicera) chillaloensis*, Scott 1939, of Abyssinia, has been recorded from Africa south of the Sahara. Dr. Scott has kindly compared this new species with the type of *A. chillaloensis*; and according to him *A. psallioticola* is larger and on the whole paler and more reddish, with less dark colour about the front part of the pronotum and the outer parts of the elytra. Its antennae are stouter and segments 3 to 8 are more inflated and bead-like, whereas in *A. chillaloensis* the segments, especially 3 to 5, have a rather long and narrow form. The pronotum has the basal part of its sides more strongly divergent, and the sides converge a little more in front, so that it appears more angular in the middle of each side. The punctures of the pronotum are a little coarser and denser. The caudal margin of the scutellum is much more strongly rounded. The elytra of the new species are relatively shorter and broader and the humeri decidedly more prominent.

NOTES ON THE BIOLOGY AND IMMATURE STAGES OF *CRYPTOPHAGUS ACUTANGULUS*, GYLL. (COL., CRYPTOPHAGIDAE).

By H. E. HINTON, Ph.D. & F. L. STEPHENS, M.Sc.

British Museum (Natural History).

Introduction.

Nineteen species of *Cryptophagus* have been recorded from houses, cellars, warehouses, mills, or granaries. It has generally been supposed that they feed on fungi, particularly moulds, but no experimental evidence is available on this point. It is not known if they can transmit fungi to uninfected stored food or other materials. To provide further information on these questions and also to describe for the first time the life-history and immature stages of *C. acutangulus*, Gyll. 1828, is the object of this paper.

C. acutangulus is widely distributed in the holarctic region, having been recorded from Europe, Siberia, Greenland, and North America. It has also been recorded from Mexico. According to Fowler (1889) it occurs in haystack and vegetable refuse and in fungi. Newbery (1912) records it in a London warehouse. Zacher (1927) records it in houses, cellars, old beer and wine barrels, and mouldy plant and animal materials. Richards and Herford (1930) found it on the walls of a London warehouse. Kunike (1934) records it in samples of cereals. Kangas (1936) records it in cellars, and Donisthorpe (1937) records it in a house at Heston at intervals over a period of two years.

The material on which this paper is based was obtained in the herbarium of the British Museum from damp decaying pods of *Bauhinia* sp. overrun by *Penicillium* and *Mucor* and from a private house exhibiting dry rot caused by the fungus *Merulius lacrymans* (Wulf.) Fr.

Food and Feeding Habits.

Several specimens were placed in a petri dish and given the following choice of foods: *Penicillium* sp., *Psalliota campestris* (Linn.) Fr., barley flour, crystallised fig, bread, coffee, chocolate, and hazel nut. After the first day their faeces contained a mixture of *Penicillium*, barley, and coffee. After the first two days some faeces consisted almost entirely of *Penicillium*, while others consisted almost entirely of *Psalliota*, and no other foods were apparently ingested. This continued to be the case on daily examination for a week and thereafter on random examination for four weeks.

Adults were fed and apparently thrived on the following fungi:—

Hymenomycetes

Psalliota campestris (Linn.) Fr. The common mushroom.

Merulius lacrymans (Wulf.) Fr. The most serious cause of dry rot of timber.

Uredinales

Puccinia antirrhini, Diet. & Holw. An important rust of snapdragons.

Ustilaginales

Ustilago avenae (Pers.) Jens. Loose smut of oats.

Pyrenomycetes

Chaetomium bostrychodes, Zopf. Occurs on dung, etc.

„ *globosum*, Kunze ex Fr. Occurs on damp paper, cloth, etc.

Discomycetes

Peziza aurantia, Pers. The "Orange peel Elf-cup" found on soil, generally in woods.

Phycomycetes

Mucor mucedo, Linn. A very common mould found on bread, fruit, fungi, dung, and other decaying substances.

Deuteromycetes

Penicillium glaucum, Link. A very common blue-green mould.

„ *camemberti*, Thom. The mould used in ripening Camembert cheese.

„ *roqueforti*, Thom. The mould used in ripening Roquefort cheese.

Botrytis cinerea, Pers. A common brownish-grey mould which can live either as a saprophyte or as a parasite; e.g., it causes blight of tulips.

These fungi were chosen as being representative of the main groups of fungi or as representing common saprophytes and parasites. No fungi so far tested have been rejected. The larvae were fed entirely on cultures of *Penicillium glaucum* and *Botrytis cinerea*.

The faeces of the beetles collected in the British Museum consisted almost entirely of hyphae and conidia of the common mould *Penicillium glaucum*. These beetles were allowed to walk in petri dishes containing sterile agar medium, and the agar plates later developed cultures of *Penicillium* sp., *Mucor* sp., and bacteria which had been attached to the external surfaces of the beetles. The faeces of the beetles which were collected in the private house contained *Penicillium* conidia and spores of *Merulius lacrymans*. Plates of sterile agar on which these beetles were allowed to walk later developed growths of *Penicillium* sp., *Saccharomyces* sp., *Actinomyces* sp., and bacteria.

Experiments were done to find out if the beetles actually digested wholly or in part the spores of fungi or if they merely ingested them. A few individuals previously starved and kept under as sterile conditions as possible were placed in dishes containing *Penicillium* conidia taken from a pure culture and free from mycelium. After four to five hours these beetles were transferred to sterile dishes, and portions of their faeces, uncontaminated by their bodies or legs, were planted in sterile water to see whether the ingested conidia would germinate. Conidia from the same original culture but which had not passed through the beetles were also sown in water under parallel conditions.

After one or two days approximately 15 per cent. of the conidia from the faeces had germinated. The conidia which had not been ingested took from five to eight days before they showed any signs of germination. The conidia of *Penicillium*, as well as those of many other fungi, germinate with difficulty if at all in sterile distilled water. It therefore appears that the passage through the alimentary canal, when it does not actually kill or disrupt the conidia, affects them so as to stimulate germination. These tests were repeated five times with comparable results, the conidia from the faeces requiring much less time for germination than those not ingested. That this is, at any rate, not directly the result of chemical stimulation due to the excretion of other substances in the pellets with the spores seems to be indicated by the fact that even after washing and shaking the pellet conidia in sterile water prior to germination an enhanced germination rate was still obtained.

The enhanced germination rate may be due to the fact that the walls of the conidia are partly digested by a cellulase or fermented by intestinal bacteria. Stimulation with tomato juice of conidia that were not eaten by the beetle resulted in approximately 70 per cent. germination in three days under the same experimental conditions.

Microscopic examination of the ingested spores showed that many of them were collapsed, irregular in shape, or had broken walls, whereas uneaten spores were approximately spherical, unbroken, and had a greater average diameter. The mean diameter of conidia which had passed through the beetles was equal to or less than 3.3μ , whereas the mean diameter of uneaten conidia was greater than 3.3μ .

Three specimens were fed for three weeks on *Penicillium* conidia only which were changed daily in case by chance they should germinate and produce hyphae. During this time no departure from the normal behaviour of the beetles could be detected, and to all appearances they seemed to be satisfied with a diet consisting exclusively of conidia.*

Life-history.

The various stages were kept in petri dishes and test-tubes containing cultures of *Penicillium* and *Botrytis cinerea* on Sabouraud's and potato dextrose agar, hazel nut, and crystallised fig. All the work on the life-history, as well as the experiments described above, were done in an average temperature of $68^{\circ}\text{F.} \pm 1$, with a minimum of 63° and a maximum of 72° .

The adults copulate in the usual manner, the male climbing upon the back of the female. The hind tarsi are normally placed obliquely across the apical part of each elytron, the middle tarsi just behind the middle, and the front tarsi near base of elytron in an oblique line from near suture to humerus. The middle and hind tarsi extend over the lateral margins of the elytra. The mouth-parts of the male extend to apical three-fourths of the pronotum of the female. The usual time taken for copulation in the specimens observed was between five and seven minutes. One male was seen to copulate with two different females within a few minutes. The female usually remains motionless until the male has left her back. When copulating the male usually moves its antennae rapidly up and down along the sides of the pronotum of the female, this movement of the antennae being accompanied by a rapid lateral twitching of the head and, to a lesser extent, the pronotum. There is frequently at the same time a slight twitching of the first two pairs of legs.

The eggs are deposited singly. One female kept in a test-tube containing a culture of *Botrytis cinerea* deposited seven eggs between the 7th and 20th January. The eggs are usually laid amongst or on top of the hyphae. One female kept from 2nd March to 18th April, laid 139 eggs. The female first mentioned laid four eggs among the strands of cottonwool near the surface of the plug of the test-tube. There is apparently no attempt to conceal the eggs, but eggs deposited on the mycelium are generally completely covered by hyphae in a day or two. The eggs hatch in five or six days. Two eggs laid on the 20th January hatched on the 25th.

Larvae which hatched on the 25th January moulted on the 1st or 2nd February and remained as second instar larvae until the 7th. One of these third instar larvae was isolated and kept under observation. It stopped feeding on the 12th, and crawled between two pieces of moist blotting-paper where it did not attempt to form any kind of pupal cell but remained motionless until the 17th, when it pupated. The imago emerged on the 24th. The pupae rest on their backs, usually in a crevice

* Cramer (*vide* Thom, 1930) analysed the conidia of *Penicillium glaucum*, and gave the following figures: Albumins 28.4 per cent.; "starches" 17 per cent.; alcohol extract 30.4 per cent.; ether extract 7.3 per cent.; "cellulose" 1.5 per cent.; ash 1.9 per cent.; and unclassified 3.8 per cent.

or under a bit of mouldy food. Three larvae pupated among the strands of a cottonwool plug. All of six larvae observed made no attempt whatever to construct a pupal cell.

The complete life-cycle from egg to adult took 30 days. According to Mjöberg (1906) the time taken by *C. subfumatus*, Kraatz 1856, for a complete life-cycle from egg to adult, beginning at the end of January, is 49 to 51 days as follows: 10 days for egg stage, 6-8 days for first instar larva, 9 days for second instar larva, 10 days for third instar larva, and 14 days for pupa. Newport (1850) found that the pupal stage of two specimens of *C. cellaris* (Scop. 1763) lasted from the 28th and 29th January to the 25th February. Falcoz (1924) points out that the larvae of *C. pubescens*, Sturm 1845, overwinter as prepupae, pupating at the beginning of May. The adults emerge about a month later. According to Xambeu (1901), *C. scanicus* (L. 1758) passes the winter in the larval stage, the larvae pupating at the beginning of April and the adult emerging in the middle of the same month.

When the adult emerges from the pupa it is yellowish white except for the head, antennae, and parts of the legs which are pale brown and the eyes which are black. It does not assume its normal colour until after the fourth day. The adults are long-lived, three adults collected in the British Museum on the 30th of December being still alive on 26th February.

Description of Adult.

Cryptophagus acutangulus, Gyll., Ins. Suec., 4, 1828, p. 285.

♂. Length, 1.9-2.6 mm. *Head* with facets of eyes very coarse, slightly but distinctly coarser than punctures; punctures deep and contiguous or separated, seldom by more than half a diameter. Antennae with third segment as short as, or

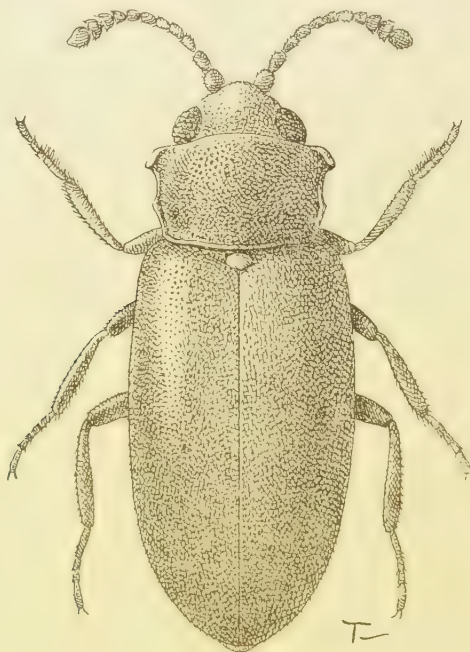


Fig. 1. *Cryptophagus acutangulus*, Gyll. ♂.

only slightly longer than, second. Clypeus with anterior margin truncate or nearly so. *Pronotum* at broadest point, which is across caudal part of thickened anterior angles, broader than long (0.71 mm. : 0.49 mm.) and breadth at base also greater than length (0.54 mm. : 0.49 mm.). Sides broadly and feebly bisinuate or nearly straight and slightly more thickly margined on basal than apical half; lateral tooth on middle of sides, prominent, and longer than an eye facet. Anterior angle occupying one-fourth of side; caudal margin produced to form a broadly rounded tooth which is separated from side by a distance equal to vertical diameter of angle; dorsal rim fine and projecting considerably above lateral margin; and outer face oval, moderately concave, and with a single coarse, nearly central puncture. Surface of pronotum with discal punctures about as coarse and dense as those of head. *Elytra* three times as long as pronotum (1.50 mm. : 0.49 mm.) and with base as broad as pronotum across apical angles. Pubescence dense and decumbent, without longer and nearly erect hairs. Surface with punctures of basal discal region slightly but distinctly finer than those of pronotal disk and usually separated by one-half to one diameter; towards apex these punctures become much finer and sparser. *Metasternum* with punctures of sides much finer and slightly sparser than those of prosternum and slightly sparser and coarser than those of metasternal episternum.

♀. Externally similar to male but with three basal segments of front tarsi more slender and less densely pubescent beneath, and with hind tarsi 5- instead of 4-segmented.

Description of Egg.

The egg (fig. 9) is 0.65 mm. long and 0.24 mm. broad, elongate, subcylindrical in cross-section, feebly curved, and rounded at each end. The surface is smooth and without a pattern, and the colour is opalescent white.

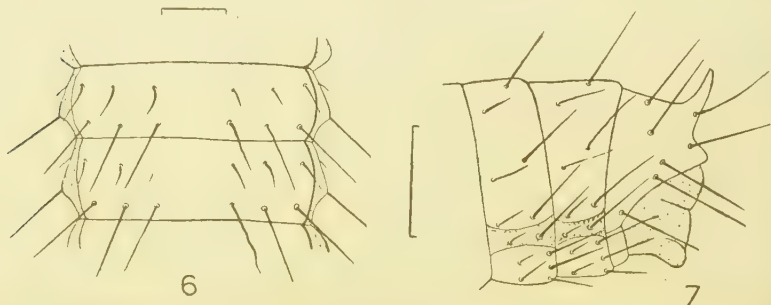
Description of Larvae (figs. 2-7).

Third instar: Length, 2.8-3.0 mm.; breadth, 0.8-0.9 mm. Body elongate and subcylindrical in cross-section. Cuticle yellowish white with most of urogomphi and mandibles brownish. *Head* with surface sparsely clothed with long, erect setae and on each side with five indistinct ocelli. Antennae (fig. 3) with first segment slightly broader and only about one-fourth as long as second; second segment with apical tubercle very broad and short; third segment slightly shorter and less than half as broad as second and at apex with a long, slender, median process. Clypeus with a complete median transverse row of four equally spaced, long, erect setae. Labrum on posterior third on each side of middle with a single long, erect seta and also with a similar seta on each side near anterior angle; sides and anterior margin with a number of similar but much shorter setae; anterior margin very feebly rounded, nearly truncate. Mandibles asymmetrical and each with two apical pointed teeth, a well developed molar surface, and a grinding area on ventral side; left mandible with four more or less acute teeth on dorsal cutting edge and with apex of prostheca (fig. 4) biind; right mandible (fig. 5) similar to left but with apex of prostheca not biind and with about four deep serrations on caudal margin. Maxilla (fig. 2) with palp 3-segmented, galea and lacinia completely fused, and chaetotaxy as figured. Labium with palp of only one segment which has several fine setae on apex and a moderately long one on outer side near base; prementum with numerous fine hairs near apical margin and on each side slightly behind inner base of palpi with a long, erect seta. *Tergites* of thorax similarly setose to those of abdomen but with a few additional setae on sides; abdominal tergites 1 to 8 with an anterior and posterior row of six setae each (fig. 6), the anterior row of setae being distinctly shorter than the posterior; ninth tergite (fig. 7) with setae and urogomphi as figured. Pleurites of abdominal segments 1 to 8 each with a long seta on posterior third and a much

shorter seta on anterior third (fig. 7). Sternites of abdominal segments 1 to 7 setose like tergites but with the anterior row of setae relatively much shorter. *Spiracles* of abdomen opening in middle of pleural membrane.



Figs. 2-5. *Cryptophagus acutangulus*, Gyll.: (2) ventral view of left maxilla of third instar larva; (3) ventral view of right antenna of same; (4) dorsal view of prostheca of left mandible of second instar larva; (5) dorsal view of right mandible of second instar larva. Lines next to all figures refer to a length of 0.20 mm, unless otherwise indicated.



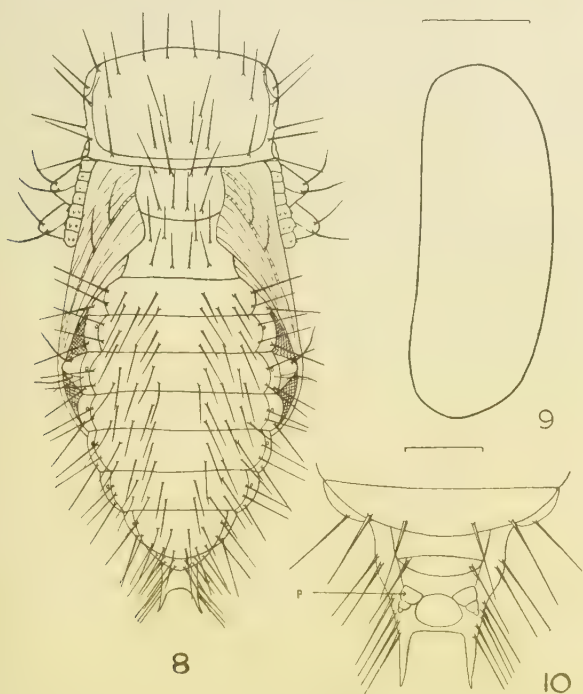
Figs. 6-7. *Cryptophagus acutangulus*, Gyll.: (6) fourth and fifth abdominal tergites of third instar larva; (7) lateral view of apex of abdomen of second instar larva.

Second instar : Similar in chaetotaxy and general proportions to mature larva but with head as broad as prothorax.

First instar : Differs from second and third instars in having the third antennal segment distinctly longer than second instead of slightly shorter. The setae are similar to those of third instar but are relatively much longer. The head is much broader than thorax, whereas in the second instar it is about as broad as prothorax and in the third instar it is much narrower than prothorax. A newly hatched larva is 0.63 mm. long and 0.24 mm. broad.

Description of Pupa.

♀ (figs. 8, 10). Length, 2.57 mm. ; breadth, 1.06 mm. Body oblong, moderately strongly convex. Cuticle shining, yellowish white, and densely and microscopically punctate ; eyes pale to dark brown (in nearly mature pupae) ; setae long, suberect to erect, and golden testaceous ; cuticle without fine, short hairs. *Head* without any part, or only with vertex, visible from above ; surface without distinct impressions and with nine setae on each side as follows : two opposite base of antenna ; one near middle mesal margin of eye ; two forming a transverse row opposite posterior third of mesal margin of eye ; one posterior to and between the latter ; and three forming an irregular transverse row on cuticle covering posterior third of eye (in one specimen examined there was a single seta on left side of head near centre). Clypeus with anterior margin broadly, arcuately emarginate ; surface with a single, moderately



Figs. 8-10. *Cryptophagus acutangulus*, Gyll. : (8) dorsal view of pupa ; (9) egg ; (10) ventral apex of abdomen of female pupa.

long seta on each side of middle. Labrum with anterior margin feebly emarginate at middle; surface without setae. Mandible with a single long seta on outer margin near apical half. Antennae extending posteriorly to a point opposite middle of metanotum; surface with a few short, obtuse tubercles which form distinct transverse rows near apical third of three terminal segments. *Pronotum* with shape and 13 setae on each side as shown in fig. 8. *Mesonotum* with a transverse row near anterior margin and one near posterior margin consisting of four setae each; surface near middle posterior margin moderately strongly gibbous; elytra extending posteriorly and ventrally to a point opposite anterior fifth of third abdominal sternite and surface with about five low convex ridges, one of the posterior ones having two long setae near base (fig. 8). *Metanotum* with an anterior and posterior row of four setae; wings extending posteriorly and ventrally to posterior third of third abdominal sternite. Abdominal tergites 1 to 7 each with seven setae on each side as follows: two forming a transverse row near anterior third; three also forming a transverse row but near posterior fifth; and two at extreme lateral margin. Tergites 1 to 6 with anterior and posterior margins truncate and 7 and 8 with posterior margin broadly rounded; 9th tergite with two moderately long, slender urogomphi (fig. 8). Pleurites of first seven abdominal segments visible from above and each with a long seta near posterior dorso-lateral angle and frequently also with a much shorter seta slightly anterior to the latter. Abdominal sternites 1 to 5 with two postero-lateral setae on each side. Apical sternites as shown in fig. 10. *Legs* with tarsi of anterior pair extending to posterior two-fifths of metasternum and separated by a distance equal to about half their lengths. Middle pair extending to posterior margin of metasternum and as widely separated as front pair. Hind pair extending nearly to posterior margin of third abdominal sternite and at apex separated by a distance equal to two-thirds the length of fifth tarsal segment. *Abdominal spiracles* opening in pleural membrane near antero-lateral sides of tergites.

♂. Similar to female but may be distinguished by 4- instead of 5-segmented hind tarsi and the absence of two palp-like processes (fig. 10) which are present on the ventral apex of the female abdomen.

Comparative notes.—The pupae of a number of other species have been described, but these descriptions, and their accompanying figures, are so inadequate that it is not possible to say in what characters, if any, they differ from *C. acutangulus*. In the collection of the British Museum there is a pupa of *C. scanicus* (L.). *C. acutangulus* differs from the latter as follows: (1) there is an anterior and posterior row of four setae on both the meso- and metanotum, whereas in *C. scanicus* both tergites have only a single seta on each side near posterior margin; (2) the first eight abdominal tergites have both a posterior and an anterior transverse row of setae, whereas in *C. scanicus* there is only a posterior row of setae on each tergite; and (3) the first six abdominal tergites have two setae on each side on or very near lateral margin, whereas in *C. scanicus* there is only a single seta on each side on lateral margin.

Summary.

An account is given of a series of experiments on the feeding habits of *Cryptophagus acutangulus*, Gyll. It was shown that this species will feed readily on a wide variety of fungi and will only rarely ingest other foods. It thrived when fed exclusively on *Penicillium* conidia. *C. acutangulus* is capable of the internal mechanical and external transmission of fungi. Approximately 15 per cent. of the *Penicillium* conidia germinate after passing through the alimentary canal, and these conidia are so affected that they have an enhanced germination rate. The larvae feed exclusively on the spores and hyphae of fungi.

A complete life-history from egg to adult is given. The larvae and pupae are described for the first time, and a description of the adult is also given.

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ON THE AFRICAN SPECIES OF *PHYLLOTRETA* (COL., HALTICINAE)

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Entomologist, Imperial Institute of Entomology.

The genus *Phyllotreta* has a world-wide range, and contains many serious pests of cultivated crops. Of the 28 described species from Africa, there are few records at present as to their food-plants. The species with yellow longitudinal bands are all very closely related to European species, and could easily be confused with them, but none in the British Museum collection agrees with described European species. G. Grandi has recorded the European species *P. nemorum*, L., from S.W. Africa, and I think it is possible that this is a misidentification. It is almost certain that all the African species will prove to be serious pests.

The following are recorded as damaging various plants, etc. These records have been forwarded by Messrs. H. W. Bedford, R. C. M. Darling, J. W. Cowland, and F. G. S. Whitfield, from the Sudan; H. Hargreaves, from Uganda; and T. J. Anderson, from Kenya:—

P. cadabae, Bry., on *Cadaba rotundifolia*, Forsk. The plant is said to be a powerful purgative.

P. capicola, Bry., on cabbage.

P. cheiranthi, Wse., on cotton, cabbage and wallflower.

P. hargreavesi, Bry., on "Jobyo" (*Gynandropsis* sp.).

P. flavifrons, Jac., on *Bamia* (*Hibiscus esculentus*, L.). The young pods used as a vegetable; the stem yields a good fibre.

P. mashonana, Jac., on turnips and radish.

P. tenuimarginata, Jac., on cotton and "Kitter" (*Acacia mellifera*, Benth.).

The fibre is used in making sacks to hold gum.

List of African Species of Phyllotreta.

<i>africana</i> , Jac.—Dtsch. ent. Zeitschr. 1895 , p. 181	...	...	W. Africa: Togo.
<i>amabilis</i> , Wse.—Arch. Nat. 69 , 1903, p. 217	...	...	Tanganyika: Kwai.
<i>capensis</i> , Jac.—Proc. Zool. Soc. Lond. 1900 , p. 240	...	...	S. Africa.
<i>capicola</i> , Bry.—Ann. Mag. Nat. Hist. (9) 14 , 1924, p. 249	...	...	S. Africa.
<i>cadabae</i> , sp. n.	...	...	Sudan.
<i>cheiranthi</i> , Wse.—Arch. Nat. 69 , 1903, p. 218	...	...	East Africa: Kwai.
<i>collaris</i> , Chap.—Ann. Mus. Genova 15 , 1880, p. 15	...	...	Abyssinia.
<i>costulata</i> , Wse.—Arch. Nat. 70 , i, 1904, p. 130	...	...	Tanganyika: Kwai.
<i>dollmani</i> , sp. n.	...	...	N. W. Rhodesia.
<i>flavifrons</i> , Jac.—Ann. Mus. Genova 39 , 1898, p. 529	...	...	Somaliland.
<i>flavilabris</i> , Wse.—Dtsch. Ent. Zeitschr. 1895 , p. 340	...	...	Gold Coast: Addah.
<i>hargreavesi</i> , Bry.—Bull. Ent. Res. 21 , 1930, p. 362	...	...	Uganda.
<i>mashonana</i> , Jac.—Proc. Zool. Soc. Lond. 1897 , p. 554	...	...	Mashonaland.
<i>milneri</i> , sp. n.	...	...	S. Africa.

<i>mombasensis</i> , Wse.—Ark. Zool. 18A , no. 34, 1927, p. 24	...	Mombasa.
<i>namvalica</i> , sp. n. ... ..	...	N.W. Rhodesia.
<i>natalensis</i> , Jac.—Proc. Zool. Soc. Lond. 1899 , p. 342...	...	Natal.
<i>memorum</i> , L.—Syst. Nat. Ed. X, p. 373; Grandi, Mem. R. Acad. Bologna (8) 9 , 1932, p. 414	...	Europe, S.W. Africa.
<i>opaca</i> , Jac. —Proc. Zool. Soc. Lond. 1897 , p. 554	...	Mashonaland.
<i>ovata</i> , sp. n. ... ..	...	S. Africa.
<i>rhodesiana</i> , sp. n. ... ..	...	N. W. Rhodesia.
<i>ruficeps</i> , Wse.—Arch. Nat. 70 , i, 1904, p. 170	...	Tanganyika: Mombo.
<i>tenuimarginata</i> , Jac.—Ann. Mus. Genova 39 , 1898, p. 528	...	Somaliland.
<i>tricolor</i> , Chap.—Ann. Mus. Genova 15 , 1880, p. 15	...	Abyssinia.
<i>turneri</i> , Bry.—Stylops, 4 , 1935, p. 183	...	S.W. Africa.
<i>unicostata</i> , Jac. —Proc. Zool. Soc. Lond. 1900 , p. 244...	...	S. Africa.
<i>usambarica</i> , Wse.—Arch. Nat. 69 , 1903, p. 217	...	Tanganyika : Kwai.
<i>weisei</i> , Jac.—Trans. Ent. Soc. Lond. 1906 , p. 13	...	S. Africa.

Key to the African Species of Phyllotreta.

1. (38). Upper surface unicolorous.
2. (23). Upper surface unicolorous including the head.
3. (7). Colour black, not nitid, shape elongate.
4. (8). Antennae in the male with the 4th and 5th segments dilated.
5. (6). Prothorax finely, the elytra more strongly punctured.....*mashonana*, Jac.
6. (5). Prothorax and elytra closely punctured.....*usambarica*, Wse.
7. (3). Colour blue, shape somewhat elongate.
8. (4). Antennae in the male with the 4th and 5th segments not dilated.
9. (11). Prothorax with the sides rounded, and not as wide as the base of the elytra.....*cheiranthi*, Wse.
10. (12). Colour blue black, shape ovate.
11. (9). Base of the prothorax almost as wide as the base of the elytra.....*capensis*, Jac.
12. (10). Colour black, nitid.
13. (15). Antennae extending to the middle of the elytra.
14. (16). Prothorax with scattered punctures.....*hargreavesi*, Bry.
15. (13). Antennae short and stout.
16. (14). Prothorax smooth.....*africana*, Jac.
17. (20). Colour opaque black.
18. (21). Shape somewhat ovate.
19. (22). Legs with the femora black, and all the tibiae flavous.....*opaca*, Jac.
20. (17). Colour bronze black, nitid.
21. (18). Shape somewhat quadrate, short and broad.
22. (19). Legs with the femora dark bronze, tibiae fulvous.....*milneri*, sp. n.
23. (2). * Upper surface unicolorous except the head.
24. (33). Front of the head fulvous.

25. (32). Elytra more or less carinate.
26. (28). Colour aeneous black.
27. (29). Punctures on the elytra subseriate.....*mombasensis*, Wse.
28. (26). Colour obscurely aeneous.
29. (27). Elytra finely punctured.
30. (31). Sides of elytra with the striae slightly impressed.....*flavilabris*, Wse.
31. (30). Elytra with the striae in double rows, the intervals at the sides slightly convex.....*ruficeps*, Wse.
32. (25). Elytra not carinate.
33. (24). Front of the head deflexed, flavous.
34. (36). Elytra finely and closely punctured, interstices granulate.
35. (37). Hind femora dark.....*flavifrons*, Jac.
36. (34). Prothorax and elytra strongly punctured.
37. (35). All the femora dark, with a metallic tinge.....*rhodesiana*, sp. n.
38. (1). Upper surface not unicolorous.
39. (48). Upper surface of the elytra without pattern, metallic green or blue.
40. (56). Upper surface without yellow longitudinal bands on the elytra.
41. (49). Head and prothorax rufous.
42. (43). Elytra bluish, carinate and finely punctured.....*costulata*, Wse.
43. (42). Elytra green, finely punctured in double rows.....*natalensis*, Jac.
44. (47). Posterior femora piceous.
45. (46). A strong costa at the side of the elytra.....*unicostata*, Jac.
46. (45). Elytra without costa, closely and irregularly punctured.
47. (44). All the femora flavous.....*cadabae*, sp. n.
48. (39). Upper surface of the elytra with a variegated pattern.
49. (41). Prothorax dark and nitid, not fulvous or rufous.
50. (51). Elytra with irregular transverse pale bands.....*turneri*, Bry.
51. (50). Elytra with four pale yellow maculae.....*dollmani*, sp. n.
52. (54). Prothorax dull testaceous, elytra without maculae.
53. (55). Elytra testaceous with the suture and margin darker.....*tenuimarginata*, Jac.
54. (52). Prothorax richly testaceous, feebly punctured.
55. (53). Elytra flavous with the sutural margin, sides and apex black.....*amabilis*, Wse.
56. (40). Upper surface black, the elytra with a longitudinal yellow band.
57. (68). The yellow band not extending to the margin below the shoulder.
58. (66). Prothorax blue black, attenuate in front.
59. (62). Longitudinal yellow band on elytra straight.
60. (61). Elytra with a broad yellow longitudinal band, narrowly margined with black. L. 2 mm.....*weisei*, Jac.
61. (60). Elytra with a longitudinal yellow band straight, broadly margined with black. L. 1.50 mm.....*capicola*, Bry.
62. (59). Longitudinal yellow band on the elytra not straight, emarginate on its outer margin, inner margin almost straight.

63. (65). Longitudinal yellow band on the elytra not incurved at base and apex
nemorum, L.
64. (67). Punctuation of the prothorax stronger than on the elytra.
65. (63). Elytra with a longitudinal yellow band curving inwards at the base and apex.....*namwalia*, sp. n.
66. (58). Prothorax black, very transverse, at its widest about as wide as the base of the elytra.
67. (64). Punctuation of the prothorax and elytra about equal.
68. (57). Longitudinal yellow band emarginate on the outer side, the yellow extending to the margin below the shoulder, incurved at the apex
ovata, sp. n.
- P. collaris*, Chap., and *P. tricolor*, Chap., both from Abyssinia, I am unable to place with certainty in the key owing to the descriptions being inadequate. They probably come near *P. natalensis*, Jac.

The types of all the six new species are in the British Museum.

***Phyllotreta milneri*, sp. n.**

Subquadrate, short and broad, entirely deep bronze, with the exception of the basal segments of the antennae and tibiae fulvous, prothorax closely and evenly punctured, the elytra with the punctures more scattered and irregular. L. 1.75-2.00 mm.

Head bronze, very finely punctured, the labrum smooth and impunctate. Antennae extending a little beyond the base of the elytra, the six basal segments fulvous, the remainder fuscous, the first segment twice as long as the second, the second to the tenth all about equal, the eleventh slightly longer and acuminate at the apex. Prothorax bronze, transverse, the sides attenuate in front, finely and closely punctured. Scutellum very small, transverse, bronze. Elytra bronze, broad and short, slightly rounded at the apex, irregularly punctured, the punctures somewhat finer towards the apex, and at the sides more regular. Legs with the femora dark bronze, all the tibiae and tarsi fulvous. Underside black. Male smaller than the female, having the front tarsi with the basal segments dilated.

SOUTH AFRICA: Capetown, Milnerton, xii.1925, ii.1926 (*R. E. Turner*), 6 specimens.

This is a broad subquadrate species, and has more the appearance of a species of *Chaetocnema*, but it has no tooth on the posterior tibiae, which excludes it from that genus.

***Phyllotreta rhodesiana*, sp. n. (fig. 1).**

Below blackish, above dark metallic green, the six basal segments of the antennae and the anterior portion of the head flavous, the legs with the femora fuscous, tinged with green, the tibiae with the median portion fuscous, the remainder fulvous. L. 3 mm.

Head with the basal portion dark metallic green, finely punctured, the anterior portion perpendicularly deflexed, flavous, its surface somewhat swollen and prominent between the insertion of the antennae. Antennae extending to the middle of the elytra, the six basal segments flavous, the five apical segments black, the basal segment the longest, about equal to the second and third together, the four terminal segments the shortest and more thickened. Prothorax slightly transverse, strongly and closely punctured, the intervals finely granulate, metallic green, the sides almost straight, the anterior angles oblique and thickened. Scutellum dark metallic green,

transverse, impunctate. Elytra dark metallic green, punctured and sculptured like the prothorax. Legs with the femora darker, tinged with green, the tibiae with the median portion fuscous, the remainder fulvous. Male with the basal segment of the anterior tarsi more dilated. Underside blackish.

N.W. RHODESIA : Namwazi, 3.vi.1914 (*H. C. Dollman*), 8 specimens.

Closely allied to *P. flavifrons*, Jac., but slightly more slender, the colour brighter green, the punctuation stronger, the basal segment of the antennae not as long, and all the femora dark.

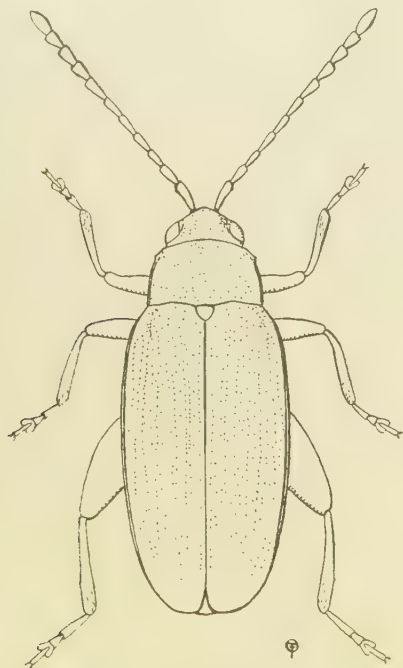


Fig. 1. *Phyllotreta rhodesiana*, sp. n.

***Phyllotreta cadabae*, sp. n.**

Oblong, depressed, the upper surface with the head and prothorax flavous, and the elytra black, the antennae and legs flavous, the six apical segments of the antennae tinged with fuscous, the ventral segments of the abdomen black. L. 1.50 mm.

Head flavous, the vertex almost smooth. Antennae long and slender extending to the middle of the elytra, flavous with the six apical segments tinged with fuscous, the first segment longer and more swollen than the second or third, the fourth longer than the third, and the remaining terminal segments each about equal to the fourth. Prothorax flavous, slightly transverse, the sides almost straight, slightly attenuate in front, very finely punctured. Scutellum flavous, triangular. Elytra long and subparallel, rounded at the apex, black, thickly and confusedly punctured, the punctuation being a little stronger than on the prothorax; Legs flavous. Underside with the prosternum flavous, the remainder fuscous or black.

ANGLO-EGYPTIAN SUDAN : Hadaliva, 30.x.1939 (*J. W. Cowland*), 3 specimens.

Reported feeding on *Cadaba rotundifolia*. In size and structure somewhat allied to *P. tenuimarginata*, Jac., from Somaliland, but in colour very distinct, unlike any known African species.

***Phyllotreta dollmani*, sp. n. (fig. 2).**

Oblong, bluish black, the front of the head, the four basal segments of the antennae and the legs except the hind femora flavous. Elytra with four ivory-coloured patches, the two basal patches more or less oblong, their inner margin incurved and the two apical irregularly rounded. L. 2 mm.

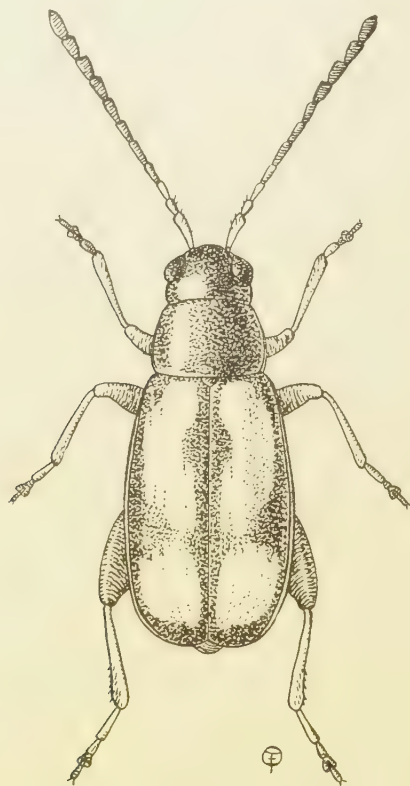


Fig. 2. *Phyllotreta dollmani*, sp. n.

Head with the basal half shining blue-black, the front flavous, impunctate. Antennae long and slender, extending to the middle of the elytra, the four basal segments flavous, the remaining apical segments fuscous, the first segment very long, as long as the second and third together, the second to the apex, all about equal to each other. Prothorax shining blue-black, very minutely punctured, transverse, the sides almost straight, the anterior angles slightly contracted. Scutellum small, blue-black, impunctate, triangular. Elytra oblong, about three times as long as the prothorax, blue-black, very finely punctured, and with four large ivory maculae, the two basal ones oblong, the inner margin incurved, extending slightly beyond the

middle, the two apical patches irregularly rounded. Legs flavous, except for the hind femora, which are blue-black, the front tarsi in the ♂ with the basal segment more expanded. Underside blue-black, tinged with fulvous, the three basal ventral segments about equal to each other, and clothed with scattered golden pubescence.

N.W. RHODESIA : Mwengwa, 3.vi.1934 (*H. C. Dollman*) ; 15 specimens.

The most nearly allied African species is *P. turneri*, Bry., from S.W. Africa, but as regards the pattern of the elytra more allied to *P. ruficollis*, Wse., from the Caucasus.

***Phyllotreta namwalica*, sp. n. (fig. 3).**

Black, the three basal segments of the antennae, and basal portion of the tibiae tinged with fulvous, head and prothorax rather strongly punctured, nitid, elytra with a longitudinal flavous band on each, curving inwards at the base and apex, the outer margin emarginate ; closely and irregularly punctured. L. 2 mm.

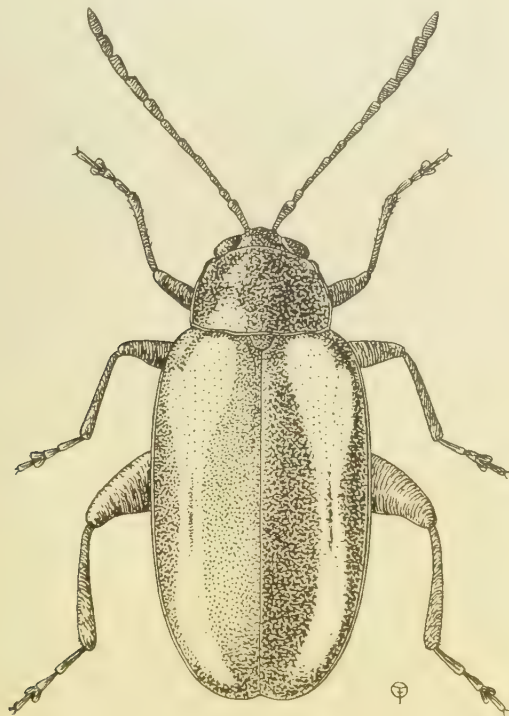


Fig. 3. *Phyllotreta namwalica*, sp. n.

Head black, nitid, the vertex rather strongly punctured, the basal portion smooth. Antennae black, the three basal segments tinged with fulvous, the basal segment the longest, a little longer than the second and third together ; the fourth to the seventh about equal to each other and more slender than the four terminal. Prothorax black, nitid, the sides attenuate in front, strongly punctured. Scutellum black. Elytra black, with a longitudinal flavous band on each, curving in at the base and

apex, emarginate on its outer side ; closely and irregularly punctured. Legs black, with the basal portion of the tibiae tinged with fulvous. Underside black. Male with the first segment of the anterior tarsi more dilated.

N.W. RHODESIA : Namwala, iii-iv.1913 (*H. C. Dollman*) ; 1 ♂ 3 ♀♀.

Allied to *P. sinuata*, Steph., from Europe, but differs in the outer margin of the longitudinal band not nearly so emarginate, the black space enclosed is not so rectangular at the base.

***Phyllotreta ovata*, sp. n.**

Oval, convex, shining black, with the base of the antennae and the legs (except the posterior femora, which are black) reddish testaceous. Prothorax black, very transverse, at its widest as broad as the base at the elytra. Elytra with a longitudinal yellow band on each, its inner margin straight, slightly incurved at the apex, the outer margin of the yellow extending to the margin below the shoulders. L. 2-2.25 mm.

Head black shining, finely but not closely punctured. Antennae black, except for the three basal segments, which are reddish testaceous, rather widely separated at the base, the basal segment the longest, as long as the second and third together. Prothorax black shining, rather strongly punctured, very transverse, with the sides rounded, at its widest about as broad as the base of the elytra. Scutellum black, impunctate. Elytra black shining, with a longitudinal yellow band on each, enclosing a common black space on the disc, the yellow extending to the margin below the shoulders, slightly incurved at the apex, the punctuation as strong as on the prothorax. Legs reddish testaceous, with the posterior femora black. Underside black.

SOUTH AFRICA : Natal, Van Reenen, Drakensberg, xi.1926, i.1927. (*R. E. Turner*) ; 2 specimens.

This is a very distinct species on account of the very transverse prothorax ; no African or European species of the banded group has it so transverse, all having the prothorax more attenuate in front.

SOME INSECTS OF ECONOMIC IMPORTANCE IN SEYCHELLES.

By DESMOND VESEY-FITZGERALD.

Notes on insects in the Seychelles have appeared from time to time during the last thirty years in the annual reports of Seychelles Department of Agriculture. These records are now mostly lost ; it is therefore the object of the present contribution to place on record such minor pests as have been collected during 1936-1939 inclusive, and have been determined by the Imperial Institute of Entomology.

The few indigenous insects which are recorded as pests are usually associated with the coconut. This fact is of interest because palms are a striking feature of the native vegetation of the islands and the present-day coconut plantations to a large extent replace former palm forests, and it is evident that some of the insects originally associated with the native palms have now adapted themselves to the coconut palm. COCCIDAE are extremely well represented ; in fact, it is doubtful if there is any other country of comparable size where these insects are so prevalent on such a wide variety of hosts. As a result of their attacks nearly every crop plant was affected and yields reduced to a minimum, and most trees, as well as rocks and buildings, were covered with a thick growth of " sooty mould " before control was established. Although Coccid parasites were present, predators were almost absent, and their recent introduction has resulted in a very great improvement in conditions. Unfortunately a list of the COCCIDAE cannot be given owing to lack of determinations, but Green (Trans. Linn. Soc., Zool.(2) **12**, 1907, pp. 197-207) gives a list of the species known from the islands at that date. The major pests of the Colony are dealt with in separate publications to which reference is made at the end of the present paper.

NEUROPTERA.

CHRYSOPIDAE.

Chrysopa flavostigma, E.-P.

Larvae predacious on the Coccid, *Icerya seychellarum*, and other mealy-bugs. Pupates within a hard cocoon, shaped like an egg, 35 mm. long, with the outside ornamented with fragments of its prey. Adult emerges through a circular hinged opening cut at one end.

ORTHOPTERA.

GRYLLACRIDAE.

Gryllacris sechellensis, I. Bol.

Adults and nymphs cut holes in paper and cloth with the object of making a shelter by folding over the cut piece and sticking it down.

RHYNCHOTA.

PENTATOMIDAE.

Acrosternum spicatum, Dist.

Nymphs puncturing the green pods of *Crotalaria anagyroides* and thereby causing brown spotting.

DELPHACIDAE.

Stenocranus sp.

Small parties of nymphs and adults feeding on the lower surface of coconut leaves. This insect is responsible for slight yellowing of the leaf and sprays much "honey-dew" over the foliage. Preyed upon by a Chrysopid larva and by jumping spiders. Specimens from Alphonse Island.

DERBIDAE.

Proutista moesta, Westw.

Adults situated on the underside of leaves of sugar-cane. In places where they have been sucking, the leaves are disfigured with lozenge-shaped patches of dead tissue margined with black and also by yellow, red and orange streaks. Damage is, however, restricted and slight. Also found on grasses and on coconut leaves.

COCCIDAE.

The more important species of coconut attacking scales are considered in a separate publication (Vesey-FitzGerald, Bull. Ent. Res., **31**, 1940, pp. 253-283). The remaining Coccids collected have not yet been determined.

ISOPTERA.

TERMITIDAE.

Microcerotermes subtilis, Wasm.

Feeding galleries amongst the cracked bark at base of trunk of coconut, but there is no sign of the insects entering living wood.

Nasutitermes (N.) *nigritus*, Wasm.

These termites construct the common "nigger-head" termitaria which are often seen on coconut trees. The insects, however, feed only on dead bark, leaf bases, etc., and do no harm to the tree.

KALOTERMITIDAE.

Kaloterms (*Neoterms*) *laticollis*, Holmgr.

This species was described from Seychelles in 1906. Feeding galleries are driven into the rotten core of coconut trunks and also extend into the living wood. The spaces in which this termite has been working become filled with a fine, moist, mud-like substance. Damage caused very slight.

RHINOTERMITIDAE.

Coptotermes truncatus, Wasm.

This is the most destructive species of termite in Seychelles, and the damage it causes is widespread. In houses it destroys wood-work and upon occasions may make raids on books and papers. This species has been recorded as damaging the wood-work of lighters, even parts below water-level (Holmgren, Trans. Linn. Soc., Zool. (2) **14**, 1910, pp. 135-148). The termitarium has been found inside a coconut trunk which had become hollow, and feeding galleries extended into living wood. This species is also responsible for the death of trees of *Eucalyptus citriodora* (essential oil crop). It seems that dead wood is always attacked in the first place, but from this the borings extend into the living wood. The attack is often below ground and the roots may be quite destroyed, thus causing the death of the tree.

COLEOPTERA.

COCCINELLIDAE.

Rodolia chermesina, Muls.

Predator on *Icerya seychellarum*.

Scymnus constrictus, Muls.

Predator on small species of mealy-bugs, on nymphs of *Pulvinaria* and possibly on *Chionaspis inday*.

Nephus oblongosignatus, Muls. var. *grinerae*, Sic.

Predator on small species of mealy-bugs.

Sticholotus madagassa, Wse.

Predator on *Diaspis pentagona* on papaw. Although a common beetle this species has never been found to feed on any of the numerous coconut scale-insects.

Chilocorus distigma, Klug.

Imported in 1936 from Tanganyika Territory. Predator on coconut-infesting and other species of scales.

Chilocorus wahlbergi, Muls.

Imported in 1936 from Tanganyika Territory. Predator on scales as above.

Chilocorus nigritus, F.

Imported in 1938 from S. India.

Exochomus ventralis, Gerst.

Imported in 1936 from Tanganyika Territory. Predator on Lecaniid scales.

Exochomus flavipes, Th.

Found on the Aldabra Group of islands, distributed during 1937 to the other islands. A useful predator on Lecaniid scales.

LYMEXYLONIDAE.

Melittomma insulare, Frm.

A very serious pest of coconuts. This species is considered in a separate publication (Vesey-FitzGerald, Bull. Ent. Res. **31**, 1941, pp. 383-398).

DYNASTIDAE.

Oryctes monoceros, Ol.

The adult does serious damage to young coconuts by boring vertically downwards into the young unfolded heart leaves. The trees receive a serious set-back on this account and some are killed. Old trees are rarely damaged, but in the neighbourhood of distilleries, where large numbers of beetles are emerging from the heaps of rotten cinnamon leaf, the crown of an old tree may be so severely damaged that the tree dies. Trees that are dying from *Oryctes* attack are sometimes mistaken for victims of "bud rot" disease. The heart dies first and the oldest leaves may remain in place at the top of the trunk for some time. Heaps of distillery waste and dead coconut trunks are the chief breeding centres for this pest, and so wherever it is causing damage these centres of infestation should be eliminated as far as possible. Young trees must be protected by receiving constant examination; if a beetle is found to be present it should be removed with a wire harpoon, and the hole from which it is taken should be plugged with coarse grit.

RUTELIDAE.

Adoretus versutus, Har.

Adults feed at night on the foliage of various ornamental plants, especially roses and some crop plants such as Japanese peppermint (essential oil crop). Considerable damage may be done, but the attack does not usually last very long. In certain cases hand collection at night with a lamp may be worth while, and a spray of a stomach poison has also helped to reduce the damage.

OEDMERIDAE.

Sessinia grisescens, Frm.

This blister beetle is very common at light during the night along the sea-coast. If it is crushed on the skin it raises a large water-blister after a lapse of a few hours.

CERAMBYCIDAE.

Stromatium barbatum, F.

Larvae bore into and damage rafters, especially those made of *Casuarina* wood.

CURCULIONIDAE.

Cratopus adpersus, Waterh.

This species has been collected only on the madreporic islands. Specimens came from Bird Island and Coetivy Island. The adult feeds on leaves of coconut, cutting out irregular portions especially near the tip of the pinnae, as well as on the foliage of other sea-side shrubs, such as *Barringtonia speciosa*, *Scaevola* sp., *Tournefortia* sp., and *Guettardia* sp.

Cratopus griseovestitus, Linell.

The species was collected in Mahé; its habits are the same as those of *C. adpersus*.

Cratopus aurostriatus, Frm.

The present species is more of an inland form, being common in the mountainous districts of Mahé, where it does considerable damage to the foliage of certain timber trees, especially to the native species *Neowormia ferruginea*.

Diocalandra frumenti, F.

The larvae of this weevil breed in dead and fermenting wood of coconut. The adult is recorded as attacking the green petiole, but damage is not severe.

Cryptorrhynchus mangiferae, F.

Beetle reared from Mango fruit.

LEPIDOPTERA.

PYRALIDAE.

Lamprosema indicata, F.

The larvae feed on the leaves of *Pueraria phaseoloides* (cover-crop plant). The edge of the leaf is folded over and held in place by half a dozen multi-stranded silk threads, and the larva skeletonises the inner surface of the leaf under this shelter. Pupation takes place in a similar shelter, the pupa being supported by a very light hammock-like cocoon. The pupal period lasts nine days. This species is parasitised by the Tachinid, *Carcelia nemorilloides*, Bezzi. The full-fed parasitised larva pupates, and after some six days the pupa splits exposing the puparia of the parasite within. The fly emerged nine days later.

Sufetula minimalis, Fletcher.

This species was described from Seychelles in 1909. The larva bores into, and feeds on, the tissue of the young root-tip of coconut. This causes the death of the part of the root attacked, but a new branch root can originate from above the place of injury. Only adventitious roots which emerge from the base of the trunk at, or slightly above, the ground-level are available for attack. The damage therefore is limited to a slight reduction in the number of young roots. The feeding larva travels from root-tip to root-tip, only resting inside its boring for a short period. The pupa is formed inside a cocoon of silk and debris which is tucked away between the growing roots.

Pyrausta phoenicealis, Hb.

Larvae feed on the leaves of Japanese peppermint and *Ocimum* sp. (essential oil crops). The leaf is folded over or two adjacent leaves are bound together with threads, and the larva feeds under this shelter on the tissue of the upper surface of the leaf, consuming in this way all the green part of the leaf and leaving only a transparent membrane. Damage done however is slight. This species is parasitised by a Braconid, *Cardiochilus fulvus*, Cam.

Sylepta derogata, F.

Larvae feed on the leaves of "Ochro," *Hibiscus esculentus* (garden vegetable). Feeding takes place at night and the larva rests during the day-time in a rolled leaf. Defoliation is sometimes severe but the crop is not always destroyed.

Crociodolomia binotalis, Zell.

Larvae defoliating "chou de chine," a garden vegetable. Severe attack completely destroys the crop because the leaves are the marketable part. Damage can be reduced by watering with a stomach poison.

Etiella behri, Zell.

The larva feeds on the tender seeds inside the pods of leguminous plants. This insect is a serious pest in the islands since it completely prevents the cultivation of pigeon pea, *Cajanus indicus*, because every pod becomes attacked before any seeds can ripen. Lima bean is attacked, and also the ripening seeds within the pod of the cover crop, *Crotalaria* sp. The larva feeds in a characteristic way: the tender unripe seed is bitten into along the surface opposite to its point of attachment and the contents of the seeds are hollowed out, but the shell is left intact. Only one larva occurs in each pod. The larva usually constructs its frail cocoon inside the pod in which it has been feeding. The adult was observed to emerge eighteen days after the full-fed larva spun up. In *Crotalaria* parasite incidence is rather high, but in pigeon pea it is rare. The parasites which have been reared from *Crotalaria*-feeding larvae are an Ichneumonid, *Tarytia minuta*, Morley, and a Braconid, *Bracon* sp. The larva of this parasite emerges from the full-fed host and then constructs a rather thick, light buff-coloured cocoon beside its dead host. Lastly, a Eupelmid, *Eupelmus malgascius*, Masi, has been reared from this host.

Hymenia recurvalis, F.

Larvae feed on the leaves of *Amaranthus* (ornamental foliage plant). Incidence is sometimes locally very severe.

COSMOPTERYGIDAE.

Batracha arenosella, Wkr.

The larvae feed on the unopened male flowers of coconut, especially when these are still closely compressed in the recently split spathe. Later the larvae spin the

dead flowers together and pupate within the tangle. The cocoon is lozenge-shaped. The adult emerges ten days after the larva spins up. It seems that little actual damage is done by this insect.

Pyroderces simplex, Wlsm.

The larvae of this species were found feeding under the closely compacted mass of a Diaspid scale on the twigs of *Hibiscus abelmoschus*. It is probable that the larvae were scavenging amongst the dead COCCIDAE and not that it is predacious. Pupates in the lozenge-shaped cocoon, in the walls of which are incorporated frass pellets and fragments of scale-insects.

Pyroderces paroditis, Meyr.

Larvae feed on the dry tissue at the base of the bracts of incipient coconuts and male flowers which have died on the spadix. It appears that these nuts and flowers die as a result of physiological conditions and that the caterpillar is not responsible for any primary damage.

LYONETHIDAE.

Decadarchis minuscula, Wlsm.

Larvae feed in same place as those of *Pyroderces paroditis* and similarly are not responsible for any primary damage.

Opogona subcervinella, Wkr.

Larvae bore into stored potato tubers. The cocoon is usually made outside the tuber just at the entrance of the boring. It is lozenge-shaped and in the walls debris is incorporated. Pupal period (spinning up to emergence), seventeen to nineteen days.

GELECHIIDAE.

Dichomeris ianthes, Meyr.

Larvae feed on the leaves of *Indigofera endecaphylla* (cover crop). The leaves are spun together face to face and the larva feeds in between. Occasionally patches of this plant are attacked severely.

EUCOSMIDAE.

Spilonota rhothia, Meyr.

Larvae feeding on the leaves, especially of the young shoots, of *Eucalyptus citriodora* (essential oil crop) and *E. robusta* (a timber tree). Attack not normally serious but in a few instances young trees received a setback.

TINEIDAE.

Mastigostoma gypsatma, Meyr.

Larvae feed in the dead wood of coconut, but do not attack the living tissues.

NOCTUIDAE.

Simplicia inflexalis, Guen.

The larvae are at times responsible for serious defoliation of *Eucalyptus citriodora*.

Symitha mangiferae, Tams.

This species has been recently described (Bull. Ent. Res. **29**, 1938, p. 9). The larvae spin together and feed on the young leaves of mango. Damage is not serious.

DIPTERA.

CECIDOMYIIDAE.

Megommata seychelli, Barnes.

Larva predacious on *Pulvinaria* sp. The attack of this predator, however, does not prevent the parent Coccid from laying eggs, in fact the Dipteran probably feeds chiefly in the egg-mass under the adult Coccid. Upon emergence of the adult midge the empty pupa-cases can be seen protruding from the mass of "floss" which forms a tail behind the female *Pulvinaria*. This species was first collected on Denis I. and the specimens were determined by Dr. H. F. Barnes, who erected a new genus for this hitherto unknown species (Rev. Zool. Bot. afr., **32**, 1939, p. 333). Subsequently the midge has been noticed to be abundant in Mahé Island wherever *Pulvinaria* is found to be present.

HYMENOPTERA.

FORMICIDAE.

Technomyrmex albipes, Sm.

By far the most abundant ant in Seychelles. The economic importance of this species is due to its association with Coccids. The biology and control of this ant will be considered in a separate publication.

APIDAE.

Megachile seychellensis, Cam.

This bee causes minor damage to Derris plants and roses by cutting oval pieces out of the leaves, which it uses in the construction of its cell.

ENCYRTIDAE.

Encyrtus felix, Embl., var. *albiscapus*, Masi.

Internal parasite of *Lecanium* sp. The exit-hole is rather jagged and covered with a persistent lid. A thin inconspicuous line of excreta is left round the periphery of the cavity within the host after the parasite has emerged. Specimens from Mahé Island.

Pseudaphycus sp.

Internal parasite of mealy-bug. Up to eighteen parasites have been reared from one host. Specimens from Mahé Island.

Metaphycus sp.

Internal parasite of *Lecanium* sp. The excreta form a dark-coloured granular line round the periphery of the cavities within the host after the parasite has emerged. Specimens from Mahé Island.

Coccidoxenus sp.

Parasite of *Ceroptastes* sp. The parasite emerges through a circular hole at the end of the dorsal surface of the adult, which does not die before it has laid some eggs that hatch out successfully. Specimens from Mahé Island.

APHELINIDAE.

Coccophagus cowperi Gir.

Internal parasite of *Lecanium* sp. Parasite emerges through a circular hole at one end of the cavity left within the host. At the other end of the cavity the excreta are arranged in the form of a "U." Specimens from Mahé Island.

Coccophagus pulvinariae, Comp.

Internal parasite of *Lecanium* spp., which emerges through a circular or slightly elliptical hole in the back of the host towards one end of the cavity. Excreta as a series of pellets in the form of a "U" at the other end of the cavity. Specimens from Mahé Island, where this species is the most usual parasite reared from Lecaniids. Two parasites have been reared from a single host.

Marietta exitiosa, Comp.

Internal parasite (possibly a hyperparasite) of *Lecanium* spp. Emergence through a circular hole in the dorsal surface, unless the host has become accidentally detached from the plant. Excreta diffuse, more or less filling cavity. Specimens from Mahé Island where this species has been reared from a number of LECANIIDAE.

PTEROMALIDAE.

Mesopeltis atrocyanea Masi.

Parasite of *Ceroplastes* sp. Two females and one male were reared from one host. The parasites had pupated in the brood chamber but had emerged through a somewhat jagged hole situated at one end of the dorsal surface of the host. The *Ceroplastes* had, however, laid a few eggs. Specimens from Mahé Island.

LELAPIDAE.

Tomocera californica, How.

Internal parasite of *Ceroplastes* sp. Parasite emerges through a circular hole situated at one end of the dorsal surface of the host. Occasionally the host lays viable eggs before it dies. Excreta piled or scattered in the cavity at the opposite end to the exit-hole. Specimens from Mahé Island.

PROGRESS OF THE CONTROL OF COCONUT-FEEDING COCCIDAE IN SEYCHELLES.

By DESMOND VESEY-FITZGERALD.

Since writing my report on the establishment and work of certain predators on coconut-feeding scale-insects in Seychelles (Bull. Ent. Res., **31**, 1940, pp. 253-283) some further records of their progress have been received. These records were taken by Mr. A. Michel under the direction of the Director of Agriculture of Seychelles, to whom I am indebted for the figures. The sampling was carried out in 10 of the localities sampled previously, so that the 1940 figures represent the fourth yearly count in each of these localities. The first count in 1937 was made before the predators had been liberated, while the subsequent counts show the yearly progress in scale reduction which has been achieved since they have been active.

In the meantime a fresh predator of considerable importance has been established in the Colony.

This predator is *Chilocorus nigritus*, which was received from the Government Entomologist, Coimbatore. Sixty-six adults were shipped and of these 40 were received alive on 28th December 1938. The life-history of this species, as a predator of *Lecanium viride* on coffee in S. India, is given by Coleman & Kunhi Kannan (Dept. Agric. Mysore, Ent. Ser. Bull. no. 4).

In Seychelles, *nigritus* was found to feed freely on Diaspid scales and it was easy to rear by the same methods which had been successfully used in the breeding of *Chilocorus distigma*. However, by the time that *nigritus* arrived the "papaw scale" was extremely rare, so the rearing bags were placed on the stems of bamboo which were often covered with a common species of scale. When a generation had been reared in the bag the latter was removed and the beetles then spread by themselves on to the foliage. In this way colonies were established in coconut plantations and the beetles spread freely on to the palms, where they were later found feeding on all the species of scales present.

The successful propagation of *C. nigritus* was entirely carried out by Mr. Michel who had gained much experience in this type of work during the campaign with *C. distigma*. During 1939 it became evident that *nigritus* was firmly established. And during 1940, it is reported, this beetle has surpassed even *distigma* in abundance, and so, being the commonest predator at the present time, most of the progress reported in these notes must be attributed to this species. A particularly satisfying characteristic of *nigritus* is the readiness with which it tackles *Pinnaspis buxi*, against which the larger *distigma* was making rather slow progress.

Before considering the tables it is necessary to place on record the introduction of two other species of COCCINELLIDAE, both of which, however, failed to become established. These are firstly *Chilocorus politus*, which was received from the Government Entomologist of Mauritius on 8th December 1938. Only eight adults were received alive, and although these fed on *Ichnaspis* on *Raphia* palm they died without laying any eggs. The second was *Vedalia cardinalis* of South African stock which was transhipped to Seychelles from Mauritius. Eleven living adults were received on 7th October 1938, and these were fed on *Icerya seychellarum*. Eggs were obtained and several generations were reared in the insectary. Some liberations were made in Mahé among young *Casuarina* trees infested with *I. seychellarum*. However, no recovery of this species has ever been made, and in the end the breeding stock was abandoned.

The method employed to assess the degree of control has been fully described in the original report on this work. The 1940 figures should, therefore, be appended to the tables given at the end of this former report in order to obtain information on the continued progress of the control effected by the imported predators.

In the 1940 record of the incidence of *Ischnaspis* it will be noticed that a further striking reduction is evident. This exceeds the forecast given in the original report that a sort of balance between predator and prey would be struck at about "20 per cent. Mark I plus 50 per cent. Mark X." This increased reduction is evidently due to the feeding of the new predators, and it seems not too optimistic to hope that *Ischnaspis* will be altogether eliminated from some samples in the future.

Pinnaspis buxi has always been the most tricky of the Seychelles coconut-feeding scales and it was against this species that the chief of hopes in new predators lay. For this reason the relation of *nigrinus* to *Pinnaspis* have received special attention and reports have been received that this predator is attacking this scale satisfactorily. The 1940 record given in Table II shows that a reduction in the incidence of *Pinnaspis* has been maintained. Not only is this the case in known bad *Pinnaspis* localities, such as the highlands of Anse-Boileau, but also throughout the samples in which *Pinnaspis* showed a tendency to become more widespread during 1938 and 1939, when the imported predators first started reducing the density of *Ischnaspis*. The 1940 figures for *Pinnaspis* also indicate that the forecast given in the original report was an under-estimate.

It was also feared that the reduction of interspecific competition resulting in the reduction of the formerly dominant species, *Ischnaspis*, might lead to an increase of *Chrysomphalus ficus*. It is therefore gratifying to find that the 1940 sampling given in Table III records a sharp reduction in the incidence of this species, and the degree of control forecasted in the original report has again proved to be an under-estimate.

Table IV illustrates the progress made against *Lecanium tessellatum* and a very great reduction is again noticeable. This is very satisfactory, because it was feared that a reduction of *Ischnaspis* might have paved the way to a spread of the *Lecanium* owing to reduced interspecific competition. Such a result would have been serious owing to the very close association between this "honey-dew" producing scale and the ant *Technomyrmex*. However, South Indian workers record *C. nigrinus* as a predator on *Lecanium*, and it is therefore probable that this omnivorous Coccinellid has also attacked *L. tessellatum* on coconuts in Seychelles.

To sum up, then, records received for 1940 indicate that the control of the coconut-feeding scales in Seychelles by imported predators has been maintained. The importance of this control can only be fully realised by those who can remember the state of the palms a few years ago. At that time it is no exaggeration to say that hardly any of the older leaves were free from a close incrustation of scales on their lower surfaces and a thick blanket of "sooty mould" upon their upper surfaces. At the present time these symptoms have disappeared and the majority of the coconut leaves are as clean as is usual in other countries. What increase in yield will result from this work it is not yet possible to record. But what is certain is that the coconut industry of Seychelles is no longer embarrassed by scale-insects, and improvements in husbandry should now proceed unimpeded.

TABLE I.
Progress of the control of Ischnaspis longirostris.

Mamelle			Anse la Retraite			Cascade			Anse aux Pins Anse Boileau			Anse Dejeuner		
Sea Level	Hill Side		Sea Level	Hill Side		Sea Level	Hill Side		Sea Level	Hill Side		Sea Level	Hill Side	
3 2 1 x	3 2 1 x	3 2 1 x	3 2 1 x	3 2 1 x	3 2 1 x	3 2 1 x	3 2 1 x	3 2 1 x	3 2 1 x	3 2 1 x	3 2 1 x	3 2 1 x	3 2 1 x	3 2 1 x
— 1 7 —	6 42 —	— 6 42 —	6 27 —	1 4 42 —	— 1 4 42 —	— — —	— — —	— 2 12 —	— 3 16 —	1 18 25 —	— 1 2 8 —	— 2 4 17	— 2 4 17	— 2 4 17

TABLE II.
Progress of the control of Pinnaspis buxi.

[illegible]

THE DISTRIBUTION OF *CIMEX LECTULARIUS* IN TOWNS IN ENGLAND AND WALES.

By COLIN MATHESON, M.A., B.Sc., F.R.E.S.,
Keeper of Zoology, National Museum of Wales.

Dr. Thomas Mouffet, in his "*Insectorum Theatrum*," refers to two noble ladies living at Mortlake on the Thames, who in 1583* were alarmed by swellings on their bodies, which they were unable to account for but which their physician, Dr. Penny, explained as being caused by bed-bugs or "wall-lice." This appears to be the earliest date mentioned by any author for the occurrence of *Cimex lectularius* in Great Britain, but the fact that they were found in what was then an obscure village suggests, as Burr remarks,† that they must have been introduced into this country some time previously. A view now commonly held is that the insect is probably native to the far eastern area of the Mediterranean basin, and that like various other pests, such as rats, it was imported to England by shipping at some time prior to the date above mentioned.

An interesting piece of negative evidence is provided by the fourteenth-century French work called "*Le Ménagier de Paris*," discussed by the late Dr. Eileen Power in her "*Medieval People*;" this work, prepared by an elderly citizen of Paris between 1392 and 1394 for the guidance of his young wife, includes full instructions for the running of a household. Perusal of these instructions, remarks Dr. Power, gives the impression that the medieval housewife was engaged in a constant warfare against fleas, and the Paris householder gives lengthy and detailed instructions for ridding bedclothes, etc., of the fleas that hop among them, and also for exterminating the mosquitos and flies that swarmed in the bedrooms. Had *Cimex* been then, as it certainly was at a later date in the houses of both rich and poor, one of the recognised and worst of bedroom pests, there can be little doubt that it would have been discussed in these comprehensive directions; and it seems fair to assume that the insect was unknown in western France, and therefore probably in England, at the close of the fourteenth century. That it became established therefore in this country some time between the years 1400 and 1580 seems as near an approximation to the truth as we are likely to obtain.

For long after that date, however, it may have been confined chiefly to the seaports, for as late as 1730 John Southall, in his "*Treatise of Buggs*," stated that though not one seaport in England was free from them, in inland towns bugs were hardly known.‡ Later they became only too familiar in all parts of the country, and in the homes of the well-to-do as well as in the slums. The elaborate roofed four-poster beds of the period, with their voluminous hanging curtains, must have formed ideal haunts for the pests, and the higher the social status of the occupant the more elaborate were the trappings of the bed. Professor Walter Patton (1931, p. 420) has described how in modern times, in hot countries, mosquito curtains are a favourite hiding-place,

* Some authors (e.g., Butler, "*Household Insects*," p. 274; Ealand, "*Insect Enemies*," p. 206) give 1503 as the date of this incident, or at any rate infer that it occurred "in the early part of the sixteenth century" (Patton, 1931, p. 418); whereas others (e.g. Ritchie, "*Influence of Man on Animal Life in Scotland*," p. 421) quote the year as 1583. The discrepancy appears to be due to the fact that in the first (Latin) edition of Mouffet (1634), the date given is 1583, but the figure "8" is defective and looks rather like "0," and was thus copied in the 1658 English edition. The incident could not have occurred in 1503 since Dr. Thomas Penny, the distinguished physician referred to, was probably not yet born then—he was a contemporary of Mouffet's at Cambridge and died in 1589.

† Entomologist's Record, February 1941, p. 13.

‡ "*A Treatise of Buggs*," 2nd edition; London, 1730; p. 33.

the insects concealing themselves at the top of the net where the rods meet at a corner; and mentions how with the aid of an electric torch he has watched them, when the lights were put out, travelling down from such a corner on their way for a feed, although no trace of them could be found in bed or mattress. One has only to look through the illustrations of seventeenth- and eighteenth-century beds and their furnishings in Macquoid and Edwards's "Dictionary of English Furniture" to appreciate how applicable, *mutatis mutandis*, the foregoing remarks would be to them. Hence it is not surprising to find "The Gentleman's Magazine" for November, 1735, publishing for the benefit of its readers the following "Receipt to destroy Bugs. To every Single Ounce of Quicksilver, put the Whites of 5 or 6 eggs, mix them, and beat them well together in a Wooden Dish with a Brush, till the Globules of the Quicksilver are but just perceptible. Then after having taken the Bedstead to Pieces, and brush'd it very clean from Dust and Dirt (without Washing) rub in all the Cracks & Joints the above Mixture, letting it Dry on; nor must the Bedstead be Wash'd at any Time afterwards. By the first Application of this Method, they will in most Places be destroyed, if not, a second will not fail destroying them entirely."

The gradual disappearance of the old four-poster and its replacement by relatively plain and unadorned bedsteads of metal or wood was doubtless a factor in decreasing the prevalence of the pest, though this was more than offset, in the earlier part of the nineteenth century, by "the two main elements in the new urban complex . . . the factory and the slum," which along with "dirt and congestion, bad in themselves, brought other pests: the rats . . ., the bedbugs that infested the beds and tormented sleep,"* etc. But in modern times there has, of course, been a great improvement in the standards of public (as well as private) hygiene and in the measures adopted to maintain these standards. The sanitary departments in our towns to-day carry out large-scale fumigation of the bedding, furniture and other effects of householders in areas condemned under clearance schemes, before removal to new premises; and also disinfection, by whatever method may be considered most suitable, of houses found to be infested. From 1936 onwards the Medical Officers of Health of a large number of towns in this country have published in their Annual Reports, in accordance with the recommendations of a circular issued by the Ministry of Health, particulars of the number of houses in their town found to be infested with *Cimex lectularius*, and the number disinfested. From these and other official figures regarding housing, we can derive the following table setting out the state of affairs in eight large towns in England and Wales for the three years 1936-38 inclusive (in two instances, for 1937-38 only):—

TABLE I.

Town	1936			1937			1938		
	No. of inhabited houses	No. found infested	Per cent. infested	No. of inhabited houses	No. found infested	Per cent. infested	No. of inhabited houses	No. found infested	Per cent. infested
A	268,310	2,636	0.98	276,338	2,510	0.91	288,836	2,374	0.82
B	201,381	2,716	1.35	204,010	1,809	0.89	206,200	1,561	0.76
C	193,709	2,104	1.09	194,781	1,973	1.01	198,089	1,720	0.87
D	141,824	3,149	2.22	144,803	3,579	2.47	146,442	3,216	2.20
E	100,720	916	0.91	102,853	305	0.30	106,116	339	0.32
F	87,783	326	0.37	89,620	443	0.49	91,624	468	0.52
G	—	—	—	78,610	275	0.35	79,989	267	0.33
H	—	—	—	47,500	236	0.50	49,000	113	0.23

* Lewis Mumford, "The Culture of Cities" (1940 edition), p. 165.

The significance of these figures may be more clearly seen if we summarise them as follows :—

Town	No. of inhabited houses (average to nearest thousand, 1936-38)	Percentage of infested houses (average, 1936-38)
A	278,000	0.90
B	204,000	1.00
C	196,000	0.99
D	144,000	2.30
E	103,000	0.50
F	90,000	0.46
G	79,000	0.34
H	48,000	0.36

We appear to have here rather more precise information than has hitherto been available on the usual view that *Cimex* is generally most numerous, as Professor Patton puts it (1931, p. 418), "in congested localities in our great cities." Ignoring for the moment Town D, which will be discussed later, we have one group of very large towns in which the average percentage of infested houses is approximately unity, and a group of smaller towns in which the percentage of infested houses ranges from only one-half down to about one-third of that figure.

In view of the many factors, social, economic, and other, which may variously affect problems of this kind in each town, and may affect also the gathering of data on these problems, it is not to be expected that one would find any close correlation between the size of a particular town and the known degree of infestation*; and it would not be advisable therefore to regard the foregoing figures as a basis for comparison between individual towns or as illustrating anything more than the general principle that large towns usually show a higher proportion of infestation than smaller ones. For this reason among others it was thought best not to specify the towns by name, and they are denoted only by reference letters or numbers in this paper.

The eight towns listed in Table I were the only towns for which I had copies of the Medical Officer's Reports for more than one year; but in order to widen the basis of the enquiry, Table II has been prepared, which gives the corresponding figures for one year only (1938) for twenty-three towns in England and Wales (including those in Table I); ranging in size from over 300,000 to under 9,000 houses, or in terms of population from over 1,000,000 down to 35,000 people.

As already mentioned, no detailed correlation between size of town and percentage of infestation can be looked for; and it would not be profitable to plot the data on a graph or apply any elaborate statistical methods. It happens, however, that the twenty-three towns in the list can be classified as regards size into four groups, each containing about the same number of towns, namely—six towns of over 100,000 houses; six towns of from 100,000 down to 50,000 houses; five towns of 50,000 to 25,000 houses; and six of under 25,000 houses. Similarly, we may classify the figures showing the percentage of infestation into six classes with intervals of 0.20 between their mid-points. Generalized in this way and illustrated by means of a

* It may be mentioned, for example, that several towns have had to be omitted from both Tables I and II because the available and very useful data covering them referred only to infested council houses and not also to those built by private enterprise. The Tables given in the present paper include only towns for which figures are given in respect of both categories; but even so there are variable factors, such as the extent to which the health department is informed about infestation in privately-owned houses, and the extent to which a house may be "infested." One (Scottish) town not included in our Tables classifies the houses according to the degree of infestation found, but this is not general.

simple diagram (Table III), our data demonstrate sufficiently clearly the existence of a broad positive correlation between the order of magnitude of the town and the degree of infestation. Of the six smallest towns, with under 25,000 houses each, five come in the class of lowest infestation, with a percentage of infested houses ranging only from 0.12 to 0.30; of the six largest towns, with over 100,000 houses each, five lie in the three highest classes, with a percentage of infested houses ranging

TABLE II.

Showing the Percentage of Houses known to be infested with Cimex lectularius in 23 Towns in England and Wales in 1938.

Reference No. of Town	No. of Inhabited Houses	No. of Houses known to be infested	Percentage of Houses infested	Remarks
1*	309,966	2,736	0.88	Inland
2*	259,805	2,042	0.79	Seaport
3*	231,701	2,195	0.95	Seaport
4	225,574	2,488	1.10	Seaport
5	146,442	3,216	2.20	Inland
6	106,116	339	0.32	Seaport
7	91,624	468	0.52	Seaport
8	90,910	601	0.66	Inland
9	79,989	267	0.33	Seaport
10	68,388	150	0.22	Inland
11	62,894	413	0.66	Seaport
12	61,580	104	0.17	Inland
13	49,000	113	0.23	Seaport
14	40,588	276	0.68	Inland
15	39,112	99	0.25	Inland
16	38,157	265	0.69	Seaport
17	33,022	127	0.38	Seaport
18	24,842	59	0.23	Seaport
19	22,621	218	0.96	Seaport
20	18,661	54	0.29	Inland
21	16,747	21	0.13	Inland
22	9,049	11	0.12	Seaport
23	8,908	27	0.30	Seaport

* Towns 1, 2 and 3 in this Table correspond to Towns A, B and C in Table I, with the addition in each case of the figures for an adjacent area which, though under a separate health department, is for all practical purposes part of the same town.

from 0.79 to unity or above, and none lie in the lowest class ; while in the case of the two groups of towns of intermediate size, the majority in each group lie in the classes of intermediate infestation (between 0.31 and 0.70).

It may be noted also, as reference to Table II will show, that of the group of six towns of over 100,000 houses, the only one which comes in the intermediate instead of the higher percentage-classes of infestation is by a considerable margin the smallest in the group.

TABLE III.

Percentage of Houses known to be infested	Size of Town			
	Under 25,000 Houses	25,000-50,000 Houses	50,000-100,000 Houses	Over 100,000 Houses
Over 1.10				*
0.91-1.10	*			* *
0.71-0.90				*
0.51-0.70		* *	* *	
0.31-0.50		*	*	*
0.11-0.30	* * *	* *	* *	

Two of the towns appear to call for special comment. The first is Town 5 (Town D in Table I), in which the percentage of houses found to be infested is twice as high as for any other town in the list. It may be well to repeat here that we do not regard our data either as an absolute criterion of the degree of infestation in general or as a basis for comparison between any two towns in particular ; but assuming, as it seems legitimate to do, that this figure does indicate a very high amount of infestation in the town in question, there may be various factors concerned. The writer is not sufficiently familiar with this town to discuss the matter in detail ; one factor, however, which has impressed itself on him when visiting the town is the large number of rows of " back-to-back " houses ; each of these houses is of course structurally united to and continuous with three others, one on either side and one behind, and has only one exposed face, that looking on the street. Old houses of this type still constitute almost fifty per cent. of the total houses in the town, though this proportion is decreasing as a result of large-scale civic replanning. Bearing in mind the habits of *Cimex*, its tendency to hide behind skirting-boards, in cracks in walls, etc., and also to migrate for short distances when opportunity is available, it seems reasonable to suggest that these long rows of old houses would be particularly favourable to the multiplication and spread of the parasite.

Such houses also incidentally would seem favourable for harbouring rats, and the same is true of structural features in some much more modern buildings; one sanitary inspector reports a case where a tenant of certain premises terminated his tenancy owing to the harbourage provided for numbers of rats by the space between a brick arch and the plywood covering it—a habitat which would also be well suited for the bed-bug. In this connection it may be recalled that *Cimex* under experimental conditions has been shown to feed on the blood of rats and mice, and it may do so under natural conditions if no human victims are available. Various authors have suggested, as an explanation of the survival of the insects for long periods in vacant houses, that they may feed on juices and moisture extracted from wood and various kinds of rubbish; a suggestion now generally discredited. Rats would no doubt constitute suitable alternative hosts to man under such circumstances; and the fact that in one of the towns in Table I almost 44,700 rats are known to have been destroyed in the three years concerned is sufficient indication, if such were needed, that the insects would find no lack of victims.

The second town with an unusually high percentage of infestation for the group to which it belongs is Town 19; this comes in the group of six towns with under 25,000 houses each, but while none of the other five shows an infestation above 0.30 per cent., in this case it is 0.96 per cent. The writer is unable to suggest any reason for this unless possibly it is connected with the fact that the town is a seaport. If *Cimex lectularius* originally entered this country by means of shipping, and if, as Southall states, it was still mainly confined to seaports even two hundred years ago, it would seem not unlikely that even to-day an occasional seaport might show an unusually high incidence of infestation.*

TABLE IV.

Percentage of Houses known to be infested				Seaports		Inland Towns	
Over 1.10				*
0.91-1.10		*		
				*	*		
0.71-0.90		*		*
0.51-0.70		*		
				*	*	*	*
0.31-0.50		*		
				*	*		
0.11-0.30		*	*	*
				*	*	*	*

* The following figures probably give some indication of the state of affairs generally in ships at British ports. During the three years 1936-38 inclusive, out of a total of approximately 7,600 ships inspected at one large port, 946, or 12.4 per cent., showed variable degrees of bug infestation; another port gave a figure of 4.5 per cent. for the same period, and a third a figure of 6.2 for 1938.

Table IV was prepared in order to see whether any difference could be discerned between seaports and inland towns in this respect. The 23 towns in Table II consist of 14 seaports and nine inland towns, distributed fairly evenly throughout the list; and these are compared in the same manner as in Table III. Considerably more data would be necessary to justify any definite conclusion on this matter; it may be noted, however, that of the nine inland towns the majority (five, or 56 per cent.) come in the class of lowest infestation (0·11 to 0·30 per cent.), with only four, or 44 per cent., in the intermediate and higher classes; whereas of the 14 seaports only four, or 29 per cent., come in the low infestation class and ten, or 71 per cent., in the intermediate and higher classes. A low incidence of infestation appears to be much more frequent among inland towns than among seaports.

In conclusion, I wish to express my thanks to Dr. J. Greenwood Wilson, Medical Officer of Health for the City and Port of Cardiff, who in addition to putting at my disposal the numerous Reports on which this paper is based, has been good enough to read through the draft of the paper.

Summary.

A brief historical account of *Cimex lectularius* in England is followed by an analysis of numerical data regarding infestation in twenty-three towns in England and Wales. The data indicate that in the majority of cases the degree of infestation increases along with the order of magnitude of the town; one or two exceptional cases are discussed. Comparison of the figures for inland towns and seaports suggests, though more data are desirable, that a low degree of infestation is common in the former whereas the majority of the latter show a moderate or heavy infestation.

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COLLECTIONS RECEIVED.

The following collections were received by the Imperial Institute of Entomology between 1st January and 31st March, 1941 :—

AGRICULTURAL RESEARCH INSTITUTE, WAD MEDANI :—8 Diptera, 27 Coleoptera, 11 Lepidoptera, and 168 Orthoptera ; from the Sudan.

Prof. P. A. BUXTON, London School of Tropical Medicine :—83 *Glossina* and 4 slide preparations ; from various localities.

CHIEF ENTOMOLOGIST, PRETORIA :—63 Coleoptera, 8 Rhynchota, and 12 Orthoptera, from South Africa.

Mr. G. H. CORBETT, Government Entomologist :—119 Diptera, 100 Coleoptera, 74 Parasitic Hymenoptera, 47 other Hymenoptera, 27 Lepidoptera, 16 Rhynchota, 8 Orthoptera, and 2 Chrysopidae ; from Malaya.

CORYNDON MEMORIAL MUSEUM, NAIROBI :—939 Coleoptera, 17 Lepidoptera, 302 Rhynchota, and 40 Orthoptera ; from East Africa.

Mr. W. COTTIER :—1 species of Coccidae ; from Samoa.

M. FIASSON :—15 Siphonaptera, 4 Hippoboscidae, 20 Anoplura and 100 eggs, 7 Mallophaga, 10 Parasitic Worms, and 100 Mites ; from Venezuela.

Mr. J. L. FROGGATT, Government Entomologist :—13 Diptera, 163 Coleoptera, 42 Parasitic Hymenoptera, 114 other Hymenoptera, 33 Lepidoptera, 50 Thysanoptera, 34 Rhynchota, 5 Blattidae, 2 Planipennia, and 70 Mites ; from New Guinea.

Mr. G. H. E. HOPKINS, Medical Entomologist :—9 *Glossina* ; from Uganda.

IMPERIAL CHEMICAL INDUSTRIES, LTD. :—6 Diptera ; from the Sudan.

Mr. C. B. R. KING, Tea Research Entomologist :—15 Diptera ; from Ceylon.

Dr. R. H. LE PELLEY, Entomologist :—5 Anthribidae and 5 larvae damaging Coffee ; from Kenya Colony.

Mr. R. A. LEVER, Government Entomologist :—5 Curculionidae, 100 Parasitic Hymenoptera, and 5 Lepidoptera ; from the Fiji Islands.

NATAL MUSEUM, PIETERMARITZBURG :—30 Nycteribiidae ; from South Africa.

Mr. A. L. REYNEKE :—138 Orthoptera ; from South Africa.

Dr. A. SHULOV :—169 Coleoptera ; from Palestine.

Mr. F. G. S. WHITFIELD :—10 Siphonaptera and 11 Mites ; from England.

COLEOPTERA ASSOCIATED WITH STORED NEPAL BARLEY IN PERU.

By H. E. HINTON, Ph.D.

Department of Entomology, British Museum (Nat. Hist.).

The beetles dealt with here were collected while I was acting as entomologist to the Percy Sladen Trust Expedition to Lake Titicaca in 1937.* They were all taken on the floor and walls of a room in which Nepal barley was stored. The room—later cleared of grain and used as a dining room—was in the hacienda Camjata, Capachica Peninsula, Lake Titicaca, alt. 3,850 m. The walls were made of adobe (sun-dried brick) and the roof was thatched with *Scirpus talora*.

Of the five species concerned, two have been recorded as pests many times before, while the other three are recorded as pests for the first time here. One species, *Trigonogenius globulus*, Solier, was probably feeding on the barley itself and the other four were almost certainly living on moulds or smuts.

LATHRIDIIDAE.

Eufalloides, gen. n.

Body subparallel-sided, moderately convex. *Head* carinate; ventral sides produced and just visible from above; antennal grooves broad and deep. Eyes small, dorso-lateral, and occupying posterior angles of head. Antennae 11-segmented; club 2-segmented. Fronto-clypeal suture broad and deep; clypeus on a slightly lower plane than front of head and distinctly broader than labrum. *Pronotum* broader than head (3:2); sides strongly explanate, lateral margins not dentate; anterior half of disk with a strongly arcuate, transverse gibbosity; near base with a broad, complete, transverse depression. *Elytra* fused along suture; each elytron with six rows of coarse, round to subquadrate punctures; sutural, third, and fifth intervals elevated. Hind wings absent. *Prosternum* with process not quite attaining caudal margin of prothorax and with hypomera nearly contiguous on median line behind process. Metasternum without a median longitudinal line; metasternal episterna concealed by epipleura. Abdomen usually with five visible sternites but occasionally a small portion of a sixth is visible; first sternite without striae. *Legs* with front coxal cavities completely closed behind by hypomera; front coxae separated by about three-fifths coxal breadth; middle coxae separated almost by coxal breadth. Trochanters two to three times as long as broad. Tarsi with first segment slightly longer than second and third much longer than combined length of first two.

Genotype: *Eufalloides holmesi*, sp. n.

This genus belongs in the tribe LATHRIDIINI where it is related to *Euchionellus*, Reitter 1908, *Eufallia*, Muttkowski 1910, and *Mumfordia*, Van Dyke 1932, the only other genera which have long and slender trochanters. From *Euchionellus* it differs in having 11- instead of 10-segmented antennae, the elytra fused instead of free along the suture, and the hind wings absent instead of fully developed. From *Eufallia* it may be distinguished by the 2- instead of 3-segmented antennal club and the pronotum, which is much broader than the head and has the sides broadly dilated. From *Mumfordia* it may be distinguished by the absence of acute tubercles on the pronotum

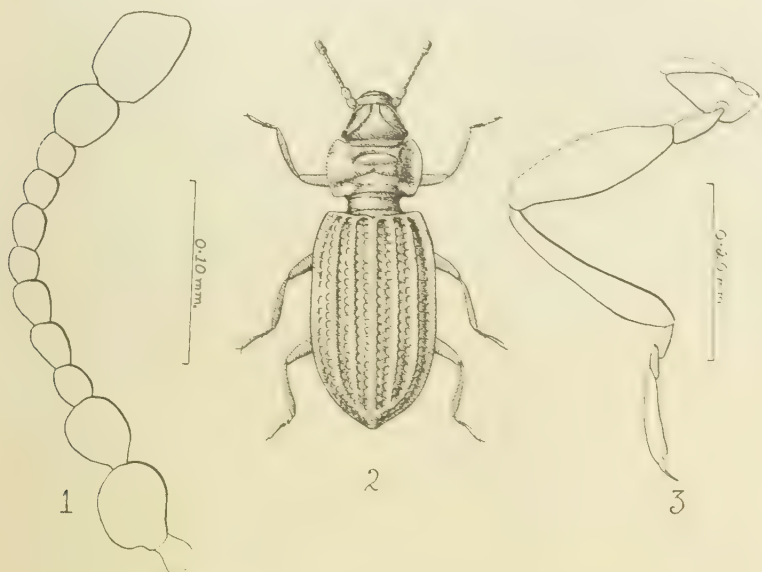
* For a general account of this expedition see Gilson, H. C., 1939, The Percy Sladen Trust Expedition to Lake Titicaca in 1937. I. Description of the Expedition.—Trans. Linn. Soc. Lond., (3) 1, pp. 1-20.

and elytra and the more or less evenly rounded instead of deeply incised sides of the pronotum. The genera of the tribe LATHRIDINI may be distinguished as follows:—

1. Trochanters two to three times as long as broad.....2
Trochanters about as long as broad.....5
2. Antennae 10-segmented.....*Euchionellus*, Reitt.
Antennae 11-segmented.....3
3. Antennal club 3-segmented. Pronotum narrower than head across eyes.....
Eufallia, Mutt.
Antennal club 2-segmented. Pronotum much broader than head across eyes...4
4. Head with granules or acute tubercles; pronotum and elytra with acute tubercles; sides of pronotum deeply incised.....*Mumfordia*, Van Dyke
Head without granules or acute tubercles. pronotum and elytra without acute tubercles; sides of pronotum more or less evenly rounded...*Eufalloides*, gen. n.
5. Pronotum with two median, subparallel, nearly complete, longitudinal carinae.....6
Pronotum without median carinae, rarely (*Enicmus*) with two indistinct carinae confined to base.....8
6. Eyes dorso-lateral and very small, separated from base of antennae by a distance equal to more than their diameter. Elytra fused along suture. Scutellum very small, not, or only scarcely, visible from above and more or less vertical, not on same plane as elytral disk. Hind wings absent or vestigial
Metophthalmus, Woll. 1854*
Eyes lateral and large, separated from base of antennae by a distance seldom equal to as much as one diameter, never by as much as two diameters. Elytra not fused along suture. Scutellum always distinctly visible from above and on same plane as elytral disk. Hind wings usually fully developed.....7
7. Pronotum with sides deeply incised at basal third. Prosternal process extending to, or nearly to, hind margin of prothorax and completely separating hypomera. Tarsi with two basal segments nearly equal in length.....
Coninomus, Thomson 1863
Pronotum with sides at most moderately sinuate at basal third. Prosternal process (with few exceptions, e.g. *L. bergrothi*, not extending to hind margin of prothorax, and hypomera meeting on median line behind prosternal process. Tarsi with first segment distinctly shorter than second.....
Lathridius, Herbst 1793
8. Middle basal part of first abdominal sternite fused to metasternum. Front and middle coxae more or less contiguous.....*Adistemia*, Fall 1899
Middle basal part of first abdominal sternite separated by a distinct suture from metasternum. Front and middle coxae distinctly separated, the former sometimes rather narrowly so.....9
9. Each elytron with 12 rows of punctures.....*Revelieria*, Perris 1869
Each elytron with not more than 8 rows of punctures.....10
10. Eyes large and seldom separated by as much as one diameter from base of antennae. Scutellum distinct and horizontal.....*Enicmus*, Thomson 1859

* *Lithostygnus*, Broun 1886, is a synonym of *Metophthalmus* (new synonymy).

Eyes usually small and separated by one or more than one diameter from base of antennae. Scutellum indistinct from above and usually more or less vertical.....*Cartodere*, Thomson 1859



Figs. 1-3. *Eufalloides holmesi*, sp. n.: (1) antenna; (2) whole insect; (3) ventral view of right hind leg.

***Eufalloides holmesi*, sp. n. (figs. 1-3).**

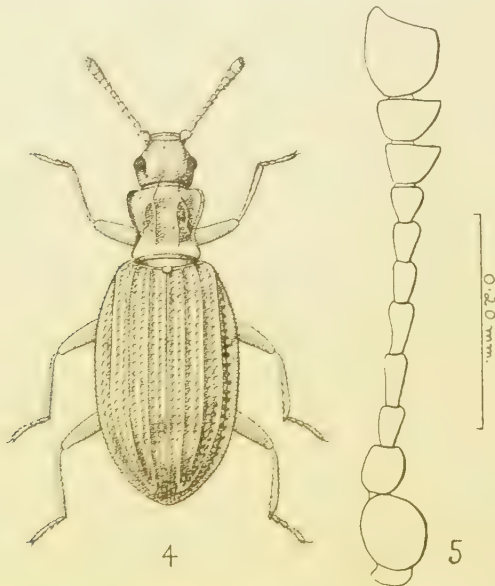
♂. Length, 1.2 mm.; breadth, 0.46 mm. Body feebly subparallel, nearly obovate; dorsal surface sparsely clothed with minute, erect hairs which are generally more evident on apex of elytra. Cuticle moderately strongly shining and brownish-testaceous; antennae and legs often slightly paler. Head across eyes broader than long (0.24 : 0.19 mm.); on each side a prominent carina extends inwards from inner side of eye to a point opposite base of antenna, and another carina extends from near ventral margin of eye to inner base of antenna; surface on each side between carinae depressed; surface feebly rugulose and finely, rather indistinctly punctate. Eyes strongly convex, about as large (0.04 mm. broad) as basal segment of antenna, and separated by twice their diameter from base of antennae. Antenna (fig. 1) as figured. Clypeus with whole of anterior margin, when seen from above, scarcely noticeably and arcuately emarginate; surface sculptured like head. Labrum with anterior margin broadly rounded. Pronotum across broadest point, which is at apical third, much broader than long (0.37 : 0.22 mm.) and base broader than apex (0.30 : 0.24 mm.). Sides broadly explanate and lateral margins microscopically serrate, more or less evenly arcuate, but nearly straight before base; base finely margined at middle; apex finely margined for most of its breadth and feebly sinuate on each side. Surface with a broad, moderately deep, complete, transverse impression on basal third, disk with a prominent, transverse, arcuate gibbosity near anterior margin and with a transverse, moderately shallow depression behind this gibbosity; surface finely, irregularly rugose and finely, densely punctate. Elytra three times as long as

pronotum (0.74 : 0.22 mm.) ; sides moderately explanate on basal four-fifths, diverging caudally from base to broadest point at basal fourth, and feebly, broadly sinuate behind basal fourth. Intervals with sutural feebly raised, third subcarinate from base to apical sixth (in some specimens nearly flat behind basal third), fifth subcarinate from basal fifth or sixth to apical sixth, and other intervals flat. Striae nowhere distinctly impressed ; stria punctures on basal half of disk round to subquadrate, deep, much broader than intervals, and separated by about one-half a diameter ; towards apex these punctures become very slightly finer. Scutellum small, indistinct, and more or less vertical, not on same plane as elytral disk. *Metasternum* distinctly shorter than first abdominal sternite (6 : 8) and without a median longitudinal line ; disk with a deep transverse depression occupying most of caudal half ; surface of disk and sides feebly rugulose and with numerous fine granules. Abdomen with basal middle of first sternite strongly declivous anteriorly ; posterior third with a deep, broad, complete, transverse impression ; sternites 2 to 5 with a similar transverse impression along anterior margin ; sternite 5 with a shallow, indistinct, transversely oval depression on middle near apex ; 6 sometimes partly visible. Surface of first five sternites sculptured like metasternal disk, but in some specimens middle region of two to five is much smoother. *Legs* (fig. 3) with a fine, long, acute spine on inner apex of all tibiae.

♀. Externally similar to ♂ but without a fine spine on inner apex of each tibia.

PERU : Lake Titicaca, Camjata (near Capachica), alt. 3,850 m., iii.v.1937 (*H. E. Hinton, P. F. Holmes*).

Type : ♂ in the British Museum (Nat. Hist.). *Paratypes* : 13, with same data as type.



Figs. 4-5 *Coninomus subfasciatus*, Reitter : (4) whole insect ; (5) antenna.

***Coninomos subfasciatus*, Reitter (figs. 4-5).**

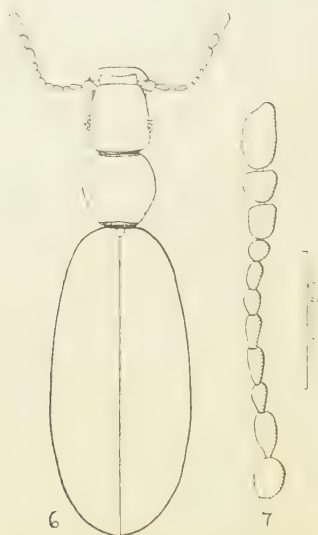
Coninomos subfasciatus, Reitter, Verh. zool.-bot. Ges. Wien, **27**, 1877, p. 183.

Four specimens of this species, previously known only from Chile, were taken. A redescription is as follows:—

♂. Length, 2.4 mm. Body moderately elongate, subparallel-sided, moderately convex; dorsal surface nearly glabrous, sparsely clothed only with extremely short, erect hairs. Cuticle shining and moderately pale reddish-brown to brownish-testaceous; middle of elytra with a large, indistinct, darker brown patch. *Head* with a moderately shallow and broad, median depression extending from base to anterior margin; surface coarsely, rugosely punctate, the punctures often larger than facets of eyes and confluent to separated by one diameter. Eyes nearly round, strongly convex, 0.11 mm. broad, and separated by three-fourths a diameter from base of antennae; temples nearly parallel and about as long as eyes. Antenna (fig. 5) with club 3-segmented and segment 8 as broad as long. Clypeus with anterior margin shallowly sinuate for its entire breadth; surface not rugose; punctures slightly finer than facets of eyes and separated by less than one to two diameters. Labrum with anterior margin broadly rounded; surface more finely and sparsely punctate than clypeus. *Pronotum* across broadest point, which is at apical sixth or seventh, not quite as broad as long (0.49 : 0.52 mm.) and base broader than apex (0.43 : 0.35 mm.). Sides deeply and broadly sinuate at basal third, elsewhere arcuate; lateral margins narrowly but nearly vertically flexed upwards. Base nearly truncate; with a complete and moderately deep and broad marginal line. Apex margined like base but on each side of middle with marginal line interrupted by median carinae. Pronotum with a moderately broad and shallow (deeper at sides), complete, transverse impression on basal third; median longitudinal carinae prominent and extending from basal seventh to near apex; on apical third of disk each carina is feebly arcuate outwards; from outer side of apical fourth of each carina a less distinct carina extends a short distance caudally and outwards; apical half of disk between carinae shallowly depressed; surface more coarsely but less rugosely punctate than head; basal fourth much more sparsely punctate than elsewhere and surface between punctures nearly smooth. *Elytra* three times as long as pronotum (1.56 : 0.52 mm.) and base only very slightly broader than broadest point of pronotum; from base becoming broader caudally to broadest point which is at about basal two-fifths. Elytra with a transverse, shallow indistinct depression on disk on basal fifth; immediately in front of apical declivity with an oval, moderately deep depression which extends on either side to third interval; middle sides of intervals 7 and 8 with a shallow, oblong depression. Each elytron with sutural interval moderately elevated on basal fourth and nearly flat elsewhere; intervals 3, 5 and 7 strongly and evenly carinate from base to slightly beyond beginning of apical declivity. Each elytron with eight feebly impressed, punctate striae; stria punctures on basal half of disk deep, round to subquadrate, as broad as, to one fourth broader than, intervals, and separated longitudinally by three-fourths to one diameter. *Mesosternum* deeply and narrowly depressed between coxae. *Metasternum* with median longitudinal depression deep, very broad, and present on caudal half; on each side behind middle coxa with a deep, broad, oval depression from which radiate a number of fine, elevated lines; disk moderately strongly convex on each side of middle; surface with numerous microscopic punctures and with a few indistinct granules slightly finer than facets of eyes. Abdomen with all of middle of first sternite between coxae shallowly depressed; on bottom of depression on each side with a deep, oval depression. Sternite 6 sometimes slightly exposed. Surface of sternites with punctures finer than facets of eyes and usually separated by two to five diameters; surface also with occasional granules which are finer than those of metasternal disk. *Legs* with a short tooth on inner apex of each tibia.

♀. Externally similar to ♂ but without tibial teeth.

Comparative notes: Close to *C. nodifer* (Westw.), but without gibbosities on the elytra.



Figs. 6-7. *Adistemia rileyi*, sp. n.: (6) outline of the type to show general proportions; (7) antenna.

***Adistemia rileyi*, sp. n. (figs. 6-7).**

♂. Length, 1.6 mm.; breadth, 0.49 mm. Body narrowly elongate, subparallel-sided, moderately depressed; dorsal surface moderately sparsely clothed with fine, long (usually longer than an eye), testaceous hairs which are more evident on elytra, where they are arranged in distinct rows. Cuticle feebly shining and brownish-testaceous to moderately pale reddish-brown; eyes pale. *Head* with breadth across eyes slightly greater than length (0.26 : 0.24 mm.); surface with moderately deep, usually round punctures nearly as coarse as facets of eyes and contiguous to seldom separated by as much as half a diameter. Eyes small (0.05 mm. broad), nearly round, moderately convex, consisting of about nine facets, and separated by two diameters from base of antennae; temples longer than eyes and feebly converging caudally. Antenna (fig. 7) with club 3-segmented. Clypeus with anterior margin nearly truncate and surface densely, indistinctly, and very much more finely punctate than head. Labrum strongly broadened and widely enclosing sides of clypeus; anterior margin broadly, shallowly, arcuately emarginate; surface sculptured like clypeus but slightly more coarsely and distinctly so. *Pronotum* very slightly broader than long (0.27 : 0.26 mm.) and base narrower than apex (0.16 : 0.19 mm.). Sides, except near base and apex, feebly dilated and moderately arcuate; base and apex with marginal line complete and distinct. Disk with a very broad, shallow, transverse depression occupying most of basal two-fifths; surface sculptured like head between eyes. *Elytra* four times as long as pronotum (1.09 : 0.26 mm.); base slightly narrower than pronotal base, and from base becoming broader caudally to broadest point which is at about basal two-fifths; apex of elytra broadly rounded, not produced. Humeri indistinct or absent. Intervals flat, but third very feebly convex on basal fourth. Each elytron with eight very feebly impressed rows of punctures; striae

punctures on basal half of disk moderately deep, flat-bottomed, more or less round, one-third broader to twice as broad as intervals, and separated longitudinally by one-half to two-thirds a diameter. *Metasternum* without a median longitudinal line; disk feebly convex or nearly flat and with round, deep punctures slightly but distinctly coarser than facets of eyes and usually separated by one-half to two-thirds a diameter. Abdomen with first sternite sculptured like metasternal disk but with a broad belt along caudal margin only microscopically alutaceous; middle basal region more or less fused to metasternum, without a distinct dividing suture. Sternites 2 to 4 with only a short anterior belt of coarse punctures and caudal part densely, microscopically alutaceous; sternite 5 without distinct coarse punctures, 2 to 5 depressed along anterior margin. *Legs* with outer face of tibiae, when viewed from side, obliquely sloping to apex. Front tarsi 2-segmented.

♀. Externally similar to male but with front tarsi 3- instead of 2-segmented.

PERU : Lake Titicaca, Camjata (near Capachica), alt. 3,850 m., iii-v.1937 (*H. E. Hinton*).

Type : ♂ in the British Museum (Nat. Hist.). Paratypes : 2 ♀♀ with same data as type.

Comparative notes : Its flat instead of carinate first, third, and seventh intervals will serve to distinguish it from the two known members of the genus. A key to the three species is as follows :—

1. Elytra with sutural, third, and seventh intervals flat or nearly so. Peru.....

A. rileyi, sp. n.

Elytra with sutural, third, and seventh intervals carinate, the latter two strongly so2

2. Length 1.0 mm. Head about as broad as long. Antennae with segments three to eight about as broad as long. Chile.....*A. bicarinata* (Belon 1897)

Length 1.2–1.7 mm. Head distinctly longer than broad. Antennae with segments three, four and five more than twice as long as broad. Europe, Madeira, Canary Is., Africa, North and South America (in houses, drugs, and herbaria).....*A. watsoni* (Woll. 1871)

This species is named in honour of Mr. N. D. Riley.

CRYPTOPHAGIDAE.

Cryptophagus cellaris (Scopoli).

Dermestes cellaris, Scopoli, Ent. Carniol., 1763, p. 16.

Seven specimens of this species were taken. It has been recorded from Europe, North Africa, Madeira, Siberia, and North America. It has not been recorded before from South America.

A summary of its habits as a pest is as follows : in a wine cork in England (Saunders, 1836) ; in houses and cellars in Germany (Erichson, 1846) ; in houses and cellars in England (Hardy & Bold, 1848) ; in a granary in Madeira (Wollaston, 1871) ; in cellars in England (Fowler, 1889) ; in a London granary (Donisthorpe, 1897, 1905) ; in a shop in Scotland (Evans, 1903) ; in a flour mill in Scotland (Beare, 1906) ; frequently in houses in England (Walker, 1907) ; in a leather factory in Cardiff (Tomlin, 1913) ; in a mouldy bread-roll at Plymouth (Keys, 1920) ; in a London warehouse on Australian sultanias (Richards & Herford, 1930) ; common in flour mills (Patton, 1931) ; in bee hives (Falcoz, 1929–1931 ; Bruce, 1936) ; in houses in the Scilly Islands (Blair, 1931) ; in pea-meal in Ireland (Welch, 1932) ; on moulds in stored rice (van Poeteren, 1933) ; in samples of cereals in Germany (Kunike, 1934) ; on dried Meloidae in Germany (Görnitz, 1937) ; and in stored wheat, barley, oats, bran, flour, seconds, sharps, ground linseed cake, etc., in England (Hayhurst, 1937).

The larva has been described by Westwood (1839) and Newport (1850) and the pupa by Newport (*l.c.*).

PTINIDAE.

Trigonogenius globulus, Solier.

Trigonogenius globulum, Solier, in Gay, Hist. Chile, **4**, 1849, p. 464, t. 11, f. 7, *a, f.*

Three adults of this cosmopolitan species were taken. A brief summary of its habits has been given by Hinton (1941).

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ON THE BIOLOGY OF *DYSDERCUS HOWARDI*, BALLOU.

II. THE EFFECT OF CONTINUED INBREEDING ON THE LIFE HISTORY.

By ELSIE I. MACGILL, M.Sc.

*University of Manchester.***Introduction.**

In July 1932 a number of Cotton Stainers, *Dysdercus howardi*, Ballou, were brought to Manchester, and since that time the insects have been bred continuously in the laboratory. During the past year (1940) there has been a certain amount of difficulty in getting supplies of cotton seed to feed the stainers, so that it has not always been possible to give them what seemed to be the best type of seed. The insects have now been bred in the laboratory for about nine years and have passed through approximately eighty generations, and it was thought that after this long period of breeding under unnatural conditions and because of the present food difficulties it might be useful to compare the early generations with those of the past eighteen months.

During the whole nine years the insects have showed practically no variations in appearance; very occasionally a melanic individual has been noticed, and once or twice a batch of eggs has produced a few insects in which the red colour has been replaced by yellow.

During 1932-34 careful counts were made of the exact numbers of eggs, nymphs and adults obtained in each generation; but after this the total numbers were not recorded, and it was not until late 1939, when the stainers appeared to be becoming less prolific, that records of all the individuals of a generation were made. In the tables for 1932-34 the generations of insects are arranged in chronological order, but one or two generations are not consecutive as occasionally full data for a generation were not available, so that this generation had to be omitted from the discussion.

Life-cycle.

The following table gives the length of the life-cycle in days for twelve generations of *Dysdercus howardi* during 1932-34 and compares with them the length of the life-cycle in twelve generations in 1940-41 :—

TABLE I.

1932-34			1940-41		
1st Eggs	1st Adult Female	Days	1st Eggs	1st Female	Days
April 21	May 25	34	Dec. 23	Jan. 24	32
June 2	July 5	33	Feb. 1	Mar. 4	32
Aug. 2	Sept. 3	32	Mar. 11	April 11	31
Sept. 16	Oct. 17	31	April 20	May 23	33
Oct. 24	Nov. 24	31	May 31	July 1	31
Dec. 1	Jan. 3	33	July 8	Aug. 8	31
Jan. 12	Feb. 13	32	Aug. 15	Sept. 16	32
Feb. 20	Mar. 24	32	Sept. 23	Oct. 22	29
April 1	May 6	35	Oct. 29	Dec. 2	34
May 15	June 20	36	Dec. 10	Jan. 14	35
June 29	July 31	32	Jan. 22	Feb. 28	37
Sept. 16	Oct. 14	28	Mar. 7	April 7	31

It will be seen from the table that there is very little difference in the length of the life-cycle of *Dysdercus howardi* at any time when the insects are kept under uniform conditions of temperature: in 1932-34 the insects took from 28 to 36 days to complete their development, but eight of the twelve generations were 31-33 days in reaching the adult stage. In 1940-41 the time of development varied from 29-37 days, but again eight of the twelve generations took 31-33 days to complete their life-cycle.

Pomeroy & Golding state that in *Dysdercus superstitionus* inbreeding lengthens the life-cycle, but a statistical test of the above figures confirms the view that in *D. howardi* the variations in the length of the life-cycle are not significant.

Oviposition.

In the earlier generations of *Dysdercus howardi* the first batch of eggs was laid approximately a week after the first female had become adult; in 1940-41 the interval between the emergence of the first female insect and the date of the first batch of eggs was also approximately seven days.

The following table compares the numbers of eggs laid by the females of the two sets of generations:—

TABLE II.

1932-34				1940-41		
Gen.	No. Females	No. Eggs	Average per female	No. Females	No. Eggs	Average per female
1	12	1,454	121.1	23	2,061	89.6
2	34	3,671	104.0	37	2,442	66.0
3	31	2,106	67.9	48	4,465	93.0
4	43	4,794	111.5	53	4,673	88.1
5	53	3,631	68.5	67	1,633	24.3
6	88	4,495	51.1	39	763	19.5
7	33	2,509	76.0	8	1,772	221.5
8	60	1,416	23.6	43	6,557	152.1
9	55	3,416	62.1	26	1,640	51.2
10	116	7,315	63.3	8	1,828	228.5
11	135	13,187	96.9	9	2,434	270.4

During 1932-34 the lowest average of eggs per female was 23.6 and the highest 121.1; in 1940-41 the lowest average was 19.5 and the highest 270.4 eggs per female. The average number of eggs for all the females was 72.7 in 1932-34 and 83.8 in 1940-41. This difference in the average number of eggs seems fairly large, but when the figures are tested the difference is found to be non-significant ($t = 1.5$ D.F. 20, $P. > 1 < .2$).

In 1932 the average number of female insects was greater than in 1940, the two averages being 60 and 32.8, and this difference is found to be just significant ($t = 2.1$ D.F. 20, $P. = .02$ -.05).

A few individual examples of the numbers of eggs laid by females in the two sets of generations are given in Table III.

TABLE III.

1932-34				1940-41			
Female emerged	Days between emergence and first eggs	No. eggs	No. batches	Female emerged	Days between emergence and first eggs	No. eggs	No. batches
April 13	8	353	3	Sept. 16	7	485	6
April 16	9	204	3	Sept. 16	7	306	3
May 1	7	199	2	Sept. 24	8	62	2
July 31	7	486	5	Dec. 2	9	281	4
Oct. 17	7	411	4	Jan. 14	8	375	4
Jan. 5	7	327	4	Feb. 28	7	487	5
Feb. 20	8	189	2	Mar. 3	7	368	5
Jan. 15	7	347	4	Mar. 3	8	134	2

Although the difference in the total number of eggs per female in the two periods is not significant, the oviposition records for the insects suggested that the 1940 females laid more, though rather smaller batches of eggs than the 1932 females. The average number of batches of eggs for 25 females in each year was found to be 2.2 for 1932-34 and 3.4 for 1940-41: this difference proved to be highly significant ($t=3.3$ Df.48. $P.<.01$).

Hatching of Egg.

In *Dysdercus howardi* many of the eggs are infertile, so that at any time the percentage of nymphs hatched is low. The following table gives the numbers of eggs and the numbers of 1st stage nymphs obtained from them in eleven generations in 1932-34 and in eleven generations in 1940-41:—

TABLE IV.

1932-34			1940-41		
Eggs	Nymphs	Percentage	Eggs	Nymphs	Percentage
1,454	831	57.0	2,061	409	19.8
3,671	1,131	30.0	2,442	428	17.5
2,106	469	22.2	4,465	443	9.9
4,794	1,032	21.5	4,673	823	17.6
3,631	646	17.7	1,633	330	20.2
4,495	1,272	28.2	763	42	5.5
2,509	668	26.6	1,772	472	26.5
1,416	171	12.1	6,557	597	9.2
3,416	1,040	30.4	1,640	41	2.5
7,315	2,396	32.7	1,828	39	2.1
3,187	3,397	25.7	2,434	310	12.7

In the earlier years the average number of eggs hatched was 28.2 per cent., with the highest percentage 57, and the lowest 12. In 1940-41 the average was 12.9 per cent., with the highest percentage 26.5 and the lowest 2.1. These results appear to show a decided decline in the fertility of the eggs in the later generations, and when the difference between them is tested it is found to be highly significant ($t=3.5$ Df.20. $P.<.01$).

Mortality of Nymphs.

The numbers of adult insects obtained from the nymphs of the two sets of eleven generations are given in the following table:—

TABLE V.

1932-34			1940-41		
1st Stage	Adults	Percentage	1st Stage	Adults	Percentage
831	93	11.1	409	86	21.7
1,131	85	7.5	428	113	26.4
469	91	19.6	443	122	27.5
1,032	123	11.8	823	156	18.9
646	130	20.1	330	104	31.5
1,272	112	8.8	42	26	61.9
668	126	18.8	472	91	19.3
171	112	65.7	597	56	9.3
1,040	244	23.4	41	14	34.1
2,396	317	13.2	39	22	56.4
3,397	339	9.6	310	94	30.3

In 1932-34 the average percentage of adults was 13.5 (highest 65.7 per cent., lowest 7.5 per cent.) and in 1940-41, 22.4 per cent. (highest 61.7 per cent., lowest 9.3 per cent.). In both years the highest percentage of adults was obtained in generations where the number of eggs hatched was very low, so that the resulting nymphs were able to receive particularly careful treatment. The two averages did seem to indicate a difference in favour of the 1940-41 generations, which might compensate to some extent for the lower fertility of the eggs, but when the figures were tested, the difference was found to be non-significant ($t=1.7$ Df.20. $P.>.05<.1$).

During each of the two periods (1932-34 and 1940-41) some of the nymphs were kept under observation to find the percentage mortality in each of the five nymphal stages. The percentage of adults obtained in both years is higher than the general average, and this is considered to be due to the insects being segregated into small lots so that overcrowding was avoided.

TABLE VI.

	Number	Percentage 1st stage reaching				
		2nd	3rd	4th	5th	Adult
1932-34 ...	1,000	82.3	59.5	50.7	42.6	26.9
1940-41 ...	630	74.1	57.1	50.8	44.4	33.5

	No.	Percent. 1st reaching 2nd	Percent. 2nd reaching 3rd	Percent. 3rd reaching 4th	Percent. 4th reaching 5th	Percent. 5th reaching Adult
1932-34 ...	1,000	82	72	85	84	61
1940-41 ...	630	74	77	89	87	75

In 1932-34 the 5th stage nymphs appear to be most vulnerable, and in the later generations mortality is highest in the first stage. The 3rd and 4th stage nymphs seem to be the most resistant in both series.

Sex Ratio.

The total number of adult insects in twelve generations in 1932-34 was 1,272 and in twelve generations in 1940-41 was 940. This 26 per cent. decrease in the number of adult insects seems large but is mainly due to three particularly small generations in the later years and when the figures are tested the difference in the numbers of adult insects is found to be non-significant ($t=1.4$ Df.22. $P.>.1<.2$).

The sex ratios for the twelve generations during the two periods are given in the following table :—

TABLE VII.

1932-34				1940-1941			
No. Adults	Female	Male	Ratio	No. Adults	Female	Male	Ratio
35	12	23	1 : 1.9	56	23	33	1 : 1.4
93	40	53	1 : 1.3	86	37	49	1 : 1.3
77	34	43	1 : 1.2	113	48	65	1 : 1.3
85	31	54	1 : 1.7	122	53	69	1 : 1.3
91	43	48	1 : 1.1	156	64	92	1 : 1.4
123	53	70	1 : 1.3	104	39	65	1 : 1.6
204	88	116	1 : 1.3	26	8	18	1 : 2.25
112	42	70	1 : 1.6	91	43	48	1 : 1.1
84	33	51	1 : 1.5	56	26	30	1 : 1.15
126	60	66	1 : 1.1	14	8	6	1 : 0.75
112	55	57	1 : 1.03	22	9	13	1 : 1.4
244	116	128	1 : 1.1	94	41	53	1 : 1.3

There is little difference in the sex ratios of the early and late generations ; in 1932-34 the ratio of the total number of females to the total number of males was 1 : 1.29 and in 1940-41 it was 1 : 1.36. In one generation in 1940 the males were more numerous than the females, but in this generation a very small number of eggs hatched and the total number of adults obtained was very small.

Summary.

1. A number of generations of *Dysdercus howardi*, Ballou, bred in the laboratory between 1932 and 1934 are compared with a similar number of generations bred from 1940 to 1941.
2. There is found to be no significant difference in the length of the life-cycle in the two periods.
3. There is a significantly greater number of adult female insects in the earlier generations of *D. howardi* (eleven generations).
4. In the later generations there is a higher percentage of infertile eggs. The difference between the two groups of insects is highly significant.
5. There is no significant difference in the percentages of nymphs becoming adult in the two periods.
6. The differences in the numbers of adult insects and in the sex ratios obtained in 1932-34 and 1940-41 are found to be non-significant (twelve generations).

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THE LATHRIDIIDAE OF ECONOMIC IMPORTANCE.

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Introduction.

The work which resulted in this paper was carried out in the Department of Entomology of the British Museum (Natural History) at the request of Professor J. W. Munro and on behalf of the Pest Infestation Laboratory of the Department of Scientific and Industrial Research.

Altogether 30 species of LATHRIDIIDAE have been recorded on stored food products or have been found in warehouses, granaries, or mills. An attempt is made here to illustrate and sufficiently to describe these species so that any of them can be quickly and accurately identified by those concerned with their control. Included in the key to the adults are a further 11 species which have been recorded in houses and cellars or which for some other reason appear likely to be found on stored food. Keys and descriptions are also given for all known larvae and pupae.

Under the headings of the species will be found summaries of their distribution, habits, life-history, and the literature relating thereto. Here for the first time complete life-histories of five species have been worked out and a nearly complete life-history for a sixth. Of the 30 species of economic importance, the following 10 have not yet been recorded from Great Britain: *Eufalloides holmesii*, Hinton, *Metopthalmus hispidus*, Belon, *Coninomus bifasciatus*, Reitt., *C. subfasciatus*, Reitt., *Enicmus protensicollis*, Mann., *E. suspectus*, Fall, *Adistemia rileyi*, Hinton, *Migneauxia orientalis*, Reitt., *Melanophthalma americana* (Mann.), and *M. picta* (Lec.).

Six of the drawings of the adults were done by Mr. A. Smith and one, *Enicmus minutus*, by Mr. A. J. E. Terzi. All other figures were drawn by me with the aid of a camera lucida. Lines next to figures refer to a length of 0.20 mm., unless otherwise indicated. The species were described for the most part under a magnification of $\times 75$.

Acknowledgments.

I have to thank Professor Munro for the opportunity of undertaking this work and the Trustees of the British Museum for allowing me to accept it. My thanks are also due to Mr. N. D. Riley and Dr. O. W. Richards for their interest and encouragement in the preparation of this paper, to the D.S.I.R. for rendering it possible to include the drawings by Mr. A. Smith, to Mr. H. Donisthorpe for allowing me to use his valuable collection of reprints, and to Miss F. L. Stephens for the identification of the fungi used in my breeding experiments.

Characters of the Family Lathridiidae.

About 33 genera and 520 species of LATHRIDIIDAE have been described. They are small (1-3 mm. long), usually obovate, convex or flattened, glabrous or pubescent, pale brown to nearly black beetles. The head is horizontal and usually more or less transverse, rarely distinctly elongate. The clypeus is on the same plane as the front of the head and is separated from it by a feebly impressed suture, or it is on a distinctly lower plane and is separated by a deep suture. The labrum is short and

usually narrower than the clypeus, but in a few (*Cartodere elegans*, *Adistemia*, *Revelieria*) it is very broad and embraces the sides of the clypeus. The oval or round eyes are usually large, prominent, and finely faceted, but in some species they are very small and consist of a few large facets. The antennae are 8- to 11-segmented with a 1- to 3-segmented club and are inserted on the sides of the front before the eyes. The maxillary palpi are 4-segmented, and the labial palpi 2- or 3-segmented. The prothorax is nearly always wider than the head, but is otherwise very variable in form. The sides are usually more or less rounded, and the margins are often finely serrate or denticulate, particularly near the hind angles. In a few genera the sides are broadly explanate. The surface of the prothorax is evenly convex or variously marked with ridges or depressions. The elytra (except in a few species of *Melanophthalma*) always completely cover the abdomen and are sometimes fused along the suture. The hind wings are usually well developed, but are absent in some genera, e.g. *Cartodere*, *Adistemia*, etc. The scutellum is usually small, distinct, and on the same plane as the elytra, but in a few genera is more or less vertical and cannot be seen from above. The abdomen has five or six free and externally visible sternites. The anterior coxae are usually conical and prominent and frequently contiguous or sub-contiguous. The hind coxae are never prominent and are always widely separated. The anterior coxal cavities are open or closed behind. The tarsal formula is 3-3-3, but in the males of some species is 2-3-3 or 2-2-3.

The larvae are elongate and subcylindrical. The head is visible from above. The ocelli are sometimes rudimentary and have no distinct cuticular lenses above the pigment spots, or they are well developed and have distinct lenses. The usual number of ocelli on each side of the head is three or four, but in those species which have rudimentary ocelli the pigment spots frequently disappear just before pupation. The antennae are 3-segmented. The mandibles of both sides are similar and are entirely sclerotised (*Eufallia*, *Coluccera*) or each has a basal sclerotised part and an apical membranous part bearing two very long, flagellate, distal setae. The membranous part of the mandible sometimes (e.g. *Cartodere*) has an inner apical, sclerotised, toothed structure. A ventral and a mesal molar grinding surface are present. The maxilla has a 3-segmented palp and an entire and obtuse mala (in *Eufallia* the maxillary mala has a distinguishable lacinia and galea). The labium is well developed and distinct, and the labial palpi are 2-segmented. The abdomen only rarely (HOLOPARAMECINI) has terminal urogomphi on the ninth segment. The annular spiracles are not situated in disk-like sclerites but open in the pleural membrane.

The adults and larvae are found in mouldy plant and animal substances, in mycetoza and fungi, in vegetable detritus, under bark and stones, and sometimes in ant and termite nests. Both stages apparently feed only* on mycetoza and fungi, particularly moulds. None of the 30 species recorded in warehouses, granaries, etc., and on stored food products is responsible for any direct injury to food, as they feed entirely on fungi. When present in numbers they may cause a certain amount of damage by dirtying the food with their faeces. They are able to transmit moulds, and in this way may cause losses. But as the spores and conidia of moulds are ubiquitous, there is little chance of their transmission by LATHRIDIIDAE to stored food which they would not have got to in any case. Control measures have been discussed by Dury (1910), Zacher (1927), Dingler (1928), Kemner (1933), and Kemper (1939). They consist of drying, heating, or fumigation. Any measures which will eliminate fungi will also eradicate Lathridiid beetles.

* Morley (1909) has recorded *Enicmus minutus* (L.) attacking *Cryptococcus fagi*, Bär., but it is probable that the *Enicmus* was only feeding on moulds growing on dead specimens of the *Cryptococcus*. I have bred *E. minutus* in numbers and found that it would eat only fungi. It never attacked dead or injured larvae of its own or other species.

*Key to Adults.**

1. Head with fronto-clypeal suture scarcely impressed but distinct and strongly arcuate; clypeus on same plane as front of head. Antennae 8-11-segmented; club of only one or two segments. Labial palpi 3-segmented. Anterior coxal cavities open behind. Hind trochanters long, at least twice as long as broad (HOLOPARAMECINI).....2
- Head as above or with fronto-clypeal suture deeply impressed and clypeus on a lower plane than front of head. Antennae 9-11 segmented; club 2-3 segmented. Labial palpi 2-segmented. Anterior coxal cavities closed behind. Trochanters short, about as broad as long (except in *Euchionellus*, *Eufallia*, *Mumfordia*, and *Eufalloides*).....4
2. Antennae 11-segmented in both sexes. Pronotum without a sublateral longitudinal stria; on each side near hind angle with a depression and with a fine but distinct, longitudinal carina which extends nearly to apical two-thirds. Cosmopolitan.....*Holoparamecus caularum* (Aubé)
- Antennae 9-segmented in ♂ and 10-segmented in ♀. Pronotum with a sublateral longitudinal stria on each side; each side near hind angle flat and without trace of a longitudinal carina or with an inconspicuous carina very close to lateral margin.....3
3. Eyes large, separated by a distance equal to one-half or less than one-half their diameter from base of antennae. Pronotum with a small discal depression and a very fine inconspicuous carina near hind angle. Metasternum distinctly longer than first abdominal sternite; with a median longitudinal impression on caudal half. Cosmopolitan.....*H. depressus*, Curtis
- Eyes small, separated by a distance equal to their diameter from base of antennae. Pronotum without a discal depression; without a carina near hind angle. Metasternum scarcely as long as first abdominal sternite; without a median longitudinal impression. Europe, Africa, Canary Is., Asia, India, North and Central America.....*H. singularis* (Beck)
4. Clypeus on a slightly lower plane than front of head; fronto-clypeal suture deep; front of head more or less coarsely and rugosely sculptured, often sulcate or carinate. Elytra frequently with elevated or even carinate intervals; surface glabrous or nearly so, seldom distinctly pubescent. Anterior coxae distinctly separated (except *Adistemia*). Abdomen usually with only five visible sternites (LATHRIDIINI).....5
- Clypeus on same plane as front of head; fronto-clypeal suture distinct but never deep; front of head sometimes coarsely punctate but never sulcate or carinate. Elytra never with elevated or carinate intervals; surface always distinctly pubescent. Anterior coxae usually contiguous or nearly so. Abdomen often with six visible sternites (CORTICARIINI).....28
5. Trochanters two to three times as long as broad.....6
- Trochanters about as broad as long.....7
6. Antennae 10-segmented. Head, pronotum, and elytra with chalky white encrustations. Elytra not fused along suture; hind wings well developed. Japan, Java, Seychelles, Germany.....*Euchionellus albofasciatus* (Reitter)*
- Antennae 11-segmented. Head, pronotum, and elytra without white encrustations. Elytra fused along suture; hind wings vestigial. Peru.....*Eufalloides holmesi*, Hinton

* Those species marked with an asterisk have been recorded only from houses or cellars.

7. Pronotum with two median, subparallel, nearly complete, longitudinal carinae. 8
Pronotum without median carinae or only rarely (*Enicmus*) with two
indistinct carinae confined to basal third.....16
8. Eyes dorso-lateral and very small, separated by a distance equal to more than
their diameter from base of antennae. Elytra fused along suture; hind
wings vestigial. Scutellum very small, scarcely visible from above, and
more or less vertical, not on same plane as elytra. *Metophthalmus*.....9
Eyes lateral and large, separated from base of antennae by a distance seldom
equal to as much as one diameter, never by as much as two diameters.
Elytra not fused together; hind wings usually fully developed. Scutellum
always distinctly visible from above and on same plane as elytra.....10
9. Antennal club 3-segmented. Elytra conspicuously setose. Chile.....
Metophthalmus hispidus, Belon
Antennal club 2-segmented. Elytra nearly glabrous. New Zealand, England.
M. serripennis (Broun)
10. Pronotum with sides deeply incised at basal third. Prosternal process extending
to, or nearly to, hind margin of prothorax and completely separating hypo-
mera (fig. 3). Tarsi with two basal segments nearly equal in length.
Coninomus.....11
Pronotum with sides at most moderately sinuate at basal third. Prosternal
process (except in *L. bergrothi*) not extending to hind margin of prothorax and
hypomera meeting on median line behind prosternal process. Tarsi with
first segment distinctly shorter than second. *Lathridius*.....14
11. Antennal club 2-segmented (fig. 4). Elytra without gibbosities or impressions.
Cosmopolitan.....*Coninomus constrictus* (Gyll.)
Antennal club 3-segmented (fig. 5). Elytra with or without conspicuous
gibbosities and/or depressions.....12
12. Elytra without distinct gibbosities or depressions; alternate intervals feebly
convex, never distinctly carinate. Australia.....*C. bifasciatus*, Reitt.
Elytra with conspicuous gibbosities and/or depressions; intervals 3, 5, and 3
distinctly carinate 17
13. Dorsal surface nearly black or very dark brown. Antenna with segment 8
twice as long as broad. Each elytron with a very prominent, broad,
longitudinal gibbosity at apical third on third interval; interval 3 feebly
convex or nearly flat from basal fifth to apical third; interval 5 much more
strongly carinate near apex than near base. Male with a very large and
prominent setose tubercle on each side of middle of metasternum near
caudal margin; hind tibia with a large tooth on inner posterior side at
apical fourth. Cosmopolitan.....*C. nodifer* (Westw.)
Dorsal surface pale brown. Antenna with segment 8 about as broad as long.
Each elytron without a gibbosity on apical third on interval 3, which is evenly
carinate on basal two-thirds; interval 5 rather evenly carinate, but slightly
less strongly carinate near apex. Male without tubercles on metasternum;
hind tibia without a preapical tooth. Chile, Peru.....*C. subfasciatus*, Reitt.
14. Species 2.3-2.8 mm. long. Elytra very strongly narrowed from near middle
to apex which is narrowly rounded and produced (fig. 14); humeri broadly
and very prominently gibbous; intervals at most feebly convex, never
carinate. Male with front and middle tibiae moderately strongly curved
and with an acute tubercle near inner apex of all tibiae. Europe, North
America.....*Lathridius lardarius* (DeG.)

- Species 1.7-2.2 mm. long. Elytra broadly rounded behind, apex not strongly narrowed and produced (fig. 15); humeri not distinctly gibbous; alternate discal intervals carinate. Male with tibiae not curved and without a tubercle near inner apex of each.....15
15. Species 1.8-2.2 mm. long. Pronotum with sides diverging anteriorly and broadly, moderately strongly sinuate. Elytra between interval 7 and lateral margin with two anterior and four posterior rows of punctures. Europe, Greenland.....*L. bergrothi*, Reitt.
- Species 1.7-1.9 mm. long. Pronotum with sides parallel and straight or nearly so. Elytra with only two rows of punctures between interval 7 and lateral margin. Europe.....*L. rugicollis* (Oliv.)*
16. Eyes large, separated by less than their diameter from base of antennae. Scutellum distinct and horizontal. *Enicmus*.....17
- Eyes small, separated by one or two diameters from base of antennae. Scutellum indistinct from above and usually more or less vertical.....19
17. Elytra broadly rounded at apex. Tibiae straight or nearly so in both sexes.† Cosmopolitan*Enicmus minutus* (L.)
- Elytra with apex slightly produced (figs. 24, 25). Tibiae moderately strongly arcuate in ♂ and feebly arcuate in ♀.....18
18. Species 2.4-2.6 mm. long. Elytra nearly twice as long as broad; intervals only feebly convex. Western North America, Aleutian Is.....*E. protensicollis* (Mann.)
- Species 2.0-2.2 mm. long. Elytra $1\frac{3}{4}$ times as long as broad; interval 3 a little convex, 5 and following intervals distinctly convex, 5 and 7 more conspicuously so. Western North America.....*E. suspectus*, Fall
19. Middle basal part of first abdominal sternite fused to metasternum. Front and middle coxae more or less contiguous. *Adistemia*.....20
- Middle basal part of first abdominal sternite separated by a distinct suture from metasternum. Front and middle coxae distinctly separated, the former sometimes rather narrowly so. *Cartodere*.....21
20. Head distinctly longer than broad. Elytra with sutural interval subcarinate; intervals 3 and 7 strongly carinate. Male with a prominent spine on mesal margin of hind coxa (fig. 27). Europe, Madeira, Canary Is., Africa, North and South America.....*Adistemia watsoni* (Woll.)
- Head with breadth across eyes slightly greater than length. Elytra with all intervals flat except third which is feebly convex near base. Male without a spine on hind coxa. Peru.....*A. rileyi*, Hinton
21. Antenna with club 2-segmented (fig. 36). Pronotum with a broad, moderately deep, oval depression on anterior half of disk. Europe, N. Africa, North and South America.....*Cartodere filum* (Aubé)
- Antenna with club 3-segmented. Pronotum without (except *C. beloni*) a distinct depression on anterior half of disk.....22
22. Pronotum as broad or nearly as broad as elytra; sides broadly explanate.....23
- Pronotum much narrower than elytra; sides not explanate.....25
23. Eyes very large and occupying hind angles of head so that temples are absent. Europe, N. Africa, N. America.....*C. argus*, Reitt.
- Eyes very small and head behind eyes with well developed temples.....24

† The section of this key separating the three species of *Enicmus* has been taken from Fall (1899), as have also the descriptions of *E. protensicollis* and *E. suspectus*.

24. Head with a broad, shallow, median longitudinal depression. Pronotum with transverse basal depression as short as apical segment of antennal club. Elytra with intervals 3, 5 and 7 subcarinate; fifth and sixth rows of punctures separated very nearly to apex. Metasternum without a transverse depression joining lateral pits. Europe, Japan, North America.....*C. costulata*, Reitt.
Head without trace of a median depression on anterior part of front. Pronotum with transverse basal depression much longer than apical segment of antennal club. Elytra with all intervals flat or at most very feebly convex; fifth and sixth rows of punctures coalescent before middle. Metasternum with lateral pits joined together by a deep, transverse depression. Europe, Asia, Japan, N. America.....*C. filiformis* (Gyll.)
25. Antennae with segments 4 and 5 nearly twice as long as broad and much longer than 3 and 6. Pronotum with a median sulcus. Europe (imported in tobacco from West Indies ?)..... *C. beloni*, Reitt.
Antennae (except in *C. ruficollis* which has segment 4 twice as long as broad and nearly twice as long as third) with segments 4 and 5 only slightly longer than broad and only slightly longer than 3 and 6. Pronotum without a median sulcus..... 26
26. Labrum broader than clypeus and enclosing sides of clypeus. Pronotum nowhere constricted. Each elytron with eight rows of punctures. Metasternum and first abdominal sternite coarsely, densely punctate. Male with front and middle tarsi 2-segmented. Europe, N. Africa, N. America.....
C. elegans (Aubé)*
Labrum narrower than clypeus and not enclosing sides of clypeus. Pronotum moderately strongly constricted near basal fourth. Each elytron with six or seven rows of punctures. Metasternum and abdomen with only a few microscopic punctures. Male with front and middle tarsi 3-segmented.....27
27. Species 1.3-1.8 mm. long. Each elytron with six rows of punctures. Metasternal disk with a deep groove on each side. Europe, N. Africa.....
C. elongata (Curtis)*
Species 1.0-1.2 mm. long. Each elytron with seven rows of punctures. Metasternal disk without a groove on each side. Europe, N. Africa, Madeira, Canary Is., North and Central America.....*C. ruficollis* (Marsh.)
28. Antennae 10-segmented. Tarsi with first two segments more or less equal in length. Europe, India, China, Japan, S. America.....
Migneauxia orientalis, Reitt.
Antennae 11-segmented. Tarsi with first segment distinctly longer than second, this being particularly noticeable in hind tarsi.....29
29. Antennal club 2- or 3-segmented. Pronotum with sides scarcely if at all crenulate; near base with a large, transverse depression. Abdomen with six sternites visible in both sexes except where antennal club is 2-segmented in which case ♂ has only five visible sternites. *Melanophthalma*.....30
Antennal club always 3-segmented. Pronotum with sides more or less strongly crenulate, particularly near base; disk near base with a broadly oval or round, median depression. Abdomen with five sternites visible in ♀ and usually six in ♂. *Corticaria*.....31
30. Species 1.2 mm. long. Antennal club 2-segmented. Abdomen with two posteriorly diverging striae on first sternite. Male without a tooth on inner apical half of front tibia. N. America (imported into Germany but not established there).....*Melanophthalma picta* (Lec.)

- Species 1.3-1.8 mm. long. Antennal club 3-segmented. Abdomen without striae on first sternite. Male with a small acute tooth on inner side of apical half of front tibia. N. America.....*M. americana* (Mann.)
31. Elytra with unequal and frequently suberect or erect hairs, the long hairs being longer than apical segment of antennal club; long and short hairs usually arranged in distinct, alternate rows.....32
- Elytra with short, subequal, decumbent hairs which are never as long as apical segment of antennal club.....35
32. Basal half of elytral disk with punctures of intervals distinctly finer than strial punctures (*Corticaria fulva* has feebly convex eyes with vertical diameter noticeably greater than horizontal; middle of first abdominal sternite with punctures distinctly finer than facets of eyes; and fifth sternite at most with a very feeble depression).....33
- Basal half of elytral disk with punctures of intervals as coarse or nearly as coarse as strial punctures (*C. pubescens* and *C. crenulata* have strongly convex and nearly round eyes; middle of first abdominal sternite with punctures as coarse as, or coarser than, facets of eyes; and fifth sternite with a deep median depression).....34
33. Metasternal disk with punctures finer than facets of eyes, shallow, and usually separated by two to three diameters. Cosmopolitan.....*Corticaria fulva* (Comolli)
- Metasternal disk with punctures as coarse as facets of eyes, and usually separated by less than two diameters. Europe, Madeira.....*C. ciliata*, Mots.*
34. Species 2.3-3.0 mm. long. Antenna with first two segments of club much longer than broad. Temples well developed. Pronotum much narrower than elytra. Cosmopolitan.....*C. pubescens* (Gyll.)
- Species 2.0-2.5 mm. long. Antenna with first two segments of club about as long as broad. Temples very short, rudimentary. Pronotum nearly as broad as elytra. Europe, Asia.....*C. crenulata* (Gyll.)
35. Basal half of elytral disk with two rows of punctures on each interval, but sometimes with these two rows not very distinct so that intervals appear to be irregularly punctate. Europe, Asia, N. America.....*C. fenestralis* (L.)
- Basal half of elytral disk with a single median row of punctures on each interval.....36
36. Species 0.9-1.0 mm. long. Australia.....*C. subtilissima*, Reitt.
- Species 1.2-2.5 mm. long.....37
37. Species 2.2-2.5 mm. long. Antenna with first segment of club distinctly longer than broad. Europe.....*C. impressa* (Oliv.)*
- Species 1.2-2.2 mm. long. Antenna with first segment of club about as broad as long or transverse.....38
38. Head behind dorsal part of eyes with well developed temples.....39
- Head behind dorsal part of eyes without distinct temples.....40
39. Pronotum broadest before middle. Basal half of elytral disk with strial punctures nearly contiguous to separated longitudinally by as much as one diameter; punctures of intervals arranged in rather regular rows and separated longitudinally by one to two diameters. Europe, Asia.....*C. longicollis* (Zett.)
- Pronotum broadest at middle. Basal half of elytral disk with strial puncture separated longitudinally by one and a half to more than two diameters; punctures of intervals usually separated longitudinally by three to four diameters. Europe, Madeira.....*C. crenicollis*, Mann.*

40. Pronotum with all of sides coarsely serrate ; anterior half of disk with punctures distinctly coarser than facets of eyes and seldom separated by as much as one diameter. Elytra with punctures of intervals near base nearly as coarse as stria punctures and on middle of disk at least half as coarse as stria punctures. Cosmopolitan.....*C. serrata* (Paykull)*

Pronotum with sides only finely serrate except near base where there are two to four coarse teeth ; anterior half of disk with punctures seldom as coarse as facets of eyes and usually separated by one to two diameters. Elytra with punctures of intervals very fine, scarcely visible near base and on middle of disk seldom more than a third as coarse as stria punctures. Cosmopolitan.....*C. elongata*, Gyll.

*Key to mature Larvae.**

1. Ninth abdominal segment with terminal urogomphi.....*Holoparamesus*, Curtis
Ninth abdominal segment without urogomphi.....2
2. Dorsal surface with setae long, slender, and round in cross section. Second segment of maxillary palp without a long seta.....3
Dorsal surface with numerous short, more or less flat, and scale-like setae (figs. 62-63). Second segment of maxillary palp (fig. 55) with a long and conspicuous seta (at least in *Corticaria fulva*).....7
3. Antenna with a long seta on apical third of second segment. Mandible without a sclerotised, toothed structure on membranous apical half (figs. 13, 18, 28)...4
Antenna without a preapical seta on second segment. Mandible with apex of membranous apical half bearing a moderately heavily sclerotised, toothed structure (figs. 42, 51).....6
4. Head with 3, 2, 1, or no pigment spots on each side ; without distinct cuticular lenses above pigment spots. Antenna (fig. 31) with second segment broader than long and not twice as long as first.....*Adistemia watsoni* (Woll.)
Head with four well developed ocelli on each side, each ocellus having a distinct lens. Antenna (figs. 12, 19) with second segment three times as long as broad and three times as long as first.....5
5. Mandible (fig. 13) with three prominent teeth on inner apical side of basal sclerotised part. Setae of dorsal surface very long and strongly curved, those of abdominal tergites frequently more than twice as long as tergites ; first eight abdominal tergites with one long and one short sublateral seta, the group of setae on each side of middle consisting of only two long and one short setae.....*Coninomus nodifer* (Westw.)
Mandible (fig. 18) without prominent teeth on inner apical side of basal sclerotised part. Setae of dorsal surface only moderately long and feebly curved, those of abdominal tergites never twice as long as tergites ; first eight abdominal tergites (fig. 17) without sublateral setae, but with median group of setae on each side of middle consisting of three long and two short setae.....*Enicmus minutus* (L.)
6. Mandible (fig. 42) with four large apical and two smaller subapical teeth on apical sclerotised structure. Antenna (fig. 38) with accessory spine arising more or less on apex of second segment. Clypeus (or front of head ?) with anterior margin broadly rounded or nearly truncate. Setae of thorax and abdomen distinctly shorter than their respective tergites (fig. 37).....*Cartodere filum* (Aubé)

* Three species of the genus *Melanophthalma* have been described, but the descriptions are so contradictory as to the structure of essential features, e.g., the mandibles, that it has not been possible to include the genus in this key.

- Mandible (fig. 51) with five large apical teeth on apical sclerotised structure. Antenna (fig. 47) with accessory spine arising well before apex of second segment. Clypeus (fig. 50) (or front of head?) with anterior margin triangularly pointed. Setae of thorax and abdomen distinctly longer than their respective tergites.....*Cartodere filiformis* (Gyll.)
7. Thorax and first eight abdominal segments (fig. 58) with all dorsal and lateral setae short, flat, and scale-like.....*Corticaria fulva* (Comolli)
- Thorax and first eight abdominal segments with some of lateral setae long, slender, and more or less round in cross section.....*Corticaria pubescens* (Gyll.)

*Key to Pupae.**

1. Abdomen with urogomphi five or more than five times as long as broad and each with apex distinctly broadened or even knobbed (figs. 21, 33, 41). Attached skin of third instar larva without flat, scale-like hairs.....2
- Abdomen with terminal urogomphi two to three times as long as broad and each with the apex not broadened (fig. 65). Attached skin of third instar larva with numerous flat, scale-like hairs (figs. 62-63).....6
2. Labrum broader than clypeus and enclosing sides of clypeus. Pronotum without a seta on caudal angle (fig. 33). Abdomen with a single row of transverse setae on each of first seven tergites (fig. 33). Legs with two setae on or near each knee. Male with front tarsi 2-segmented and hind coxa with a prominent spine on inner side.....*Adistemia watsoni* (Woll.)
- Labrum narrower than clypeus and not enclosing sides of latter. Pronotum with a seta on each caudal angle. Abdomen with two transverse rows of setae on each of first seven tergites. Legs with three setae on or near each knee. Male with front tarsi 3-segmented and hind coxa without a spine on inner side.....3
3. Hind wings present. Each seta with a distinct, more or less round knob at apex4
- Hind wings absent. Setae moderately broadened at apex and usually without a distinct apical knob.....5
4. Pronotum on each side with three setae on anterior part of disk and one near base. Mesonotum with two setae on each side; elytra with interval 3 conspicuously gibbous at apical third and 5 slightly less strongly gibbous at apical fourth; interval 5 with two setae on about basal sixth. Metanotum with three setae on each side. Male with a large gibbosity on each side near caudal margin of metasternal disk and one near inner apex of hind tibia.....
- Coninomus nodifer* (Westw.)
- Pronotum on each side with six anterior discal setae (fig. 21) and two near base. Mesonotum with a single seta on each side; elytra with intervals 3 and 5 nowhere distinctly gibbous and interval 5 without setae. Metanotum with only one seta on each side. Male without gibbosities on metasternal disk or on hind tibiae.....*Enicmus minutus* (L.)
5. Head with a deep longitudinal depression on middle of front. Antennal club 2-segmented. Pronotum with a broad and moderately deep depression on middle anterior half of disk (fig. 41).....*Cartodere filum* (Aubé)
- Head without a longitudinal depression on middle of front. Antennal club 3-segmented. Pronotum with middle anterior half of disk flat or at most feebly concave.....*Cartodere filiformis* (Gyll.)

* The last larval skin is nearly always attached to the pupa; and the pupa may be identified by the larval characters. This key is based entirely on pupal characters except for the section distinguishing the two species of *Corticaria*.

6. Attached skin of third instar larva without long, pointed, dorso-lateral setae on thorax and first eight abdominal segments (setae of dorsal surface of pupa as shown in fig. 65).....*Corticaria fulva* (Comolli)

Attached skin of third instar larva with long, pointed, dorso-lateral setae on thorax and first eight abdominal segments.....*Corticaria pubescens* (Gyll.)

Holopamecus caularum (Aubé).

Calyptobium caularum, Aubé, Ann. Soc. ent. Fr., (2) **1**, 1843, p. 244.

♂. Length, 1.0–1.2 mm.; breadth, 0.40 mm. Cuticle strongly shining and yellowish-brown to testaceous; antennae and legs usually slightly paler. Head with punctures about three-fourths as coarse as facets of eyes and separated by one to two diameters. Antennae 11-segmented and club 2-segmented. Eyes with diameter nearly equal to length of antennal club and each separated by a distance equal to half its diameter from base of antenna. Clypeus with fronto-clypeal suture distinct, strongly arcuate, and moderately shallow; anterior margin truncate; surface much more finely punctate than head. Pronotum at broadest point, which is across apical sixth or seventh, broader than long (0.34 mm. : 0.29 mm.) and base narrower than apex (0.24 mm. : 0.27 mm.). Sides completely margined and moderately strongly converging behind so that basal fourth of pronotum appears distinctly constricted; base feebly rounded for its entire breadth and with a complete marginal line. Near hind angle on each side with a deep depression and lateral to this on basal fourth with a fine but prominent longitudinal carina; at basal fourth is a shallow line which extends transversely between lateral impressions, this line being broadened at middle by two close depressions which are sometimes joined together; surface of disk evenly convex and punctate like head. Elytra more than twice as long as pronotum (0.73 mm. : 0.29 mm.) and rather noticeably broadened from base to broadest point at about basal two-fifths. Sutural stria distinct and complete; opposite scutellum extending laterally so that base is transversely margined nearly to humeri; elsewhere without striae. Surface confusedly punctate like head and pronotum but with punctures slightly finer and usually separated by three to five diameters. Metasternum distinctly longer than first abdominal sternite and with a complete median longitudinal line. Abdomen with length of first sternite at middle nearly equal to combined length of three following sternites; sixth sternite always exposed and more than half as long as fifth.

♀. Externally similar to ♂.

Comparative notes: In addition to the characters given in the key, this species may be distinguished from both *H. depressus* and *H. singularis* by its complete instead of incomplete or absent median line of the metasternal disk.

Distribution: Cosmopolitan.

Habits: In hot-beds, decaying vegetable matter, and in dung-heaps in England (Fowler, 1889); in stored rice in Denmark (Belon, 1897); under bark in California (Fall, 1899); and in a bone-sack heap in Britain (Fowler & Donisthorpe, 1913).

Holopamecus depressus, Curtis (fig. 1).

Holopamecus depressus, Curtis, Ent. Mag., **1**, 1833, p. 186.

Calyptobium kunzei, Aubé, Ann. Soc. ent. Fr., (2) **1**, 1843, p. 245.

♂. Length, 1.0–1.4 mm.; breadth, 0.45–0.55 mm. Cuticle strongly shining and dark to pale brownish-testaceous. Head with punctures distinctly finer than facets of eyes and separated by two to four diameters; surface between punctures smooth. Antenna 9-segmented and with third segment as long as second; club 2-segmented with apical segment slightly narrower and much shorter than first.

Eyes large (diameter greater than basal segment of antennal club) and separated by less than one-half (rarely as much as one-half) their diameter from base of antennae. Clypeus with fronto-clypeal suture distinct, strongly arcuate, and moderately shallow; anterior margin truncate; surface punctate like middle of head. *Pronotum* at broadest point, which is across apical sixth or seventh, broader than long (0.41 : 0.32 mm.) and base very slightly broader than apex (0.34 : 0.32 mm.). Sides completely and finely margined, moderately strongly converging behind, and broadly sinuate before hind angles; base finely, completely margined and broadly, scarcely noticeably sinuate on each side. *Pronotum* (fig. 1) on each side near hind angle not depressed but with a very fine and inconspicuous longitudinal carina close to lateral margin; on each side on basal fourth between middle and lateral margin with a longitudinal stria, the apices of the two striae being joined by a transverse stria; from base in front of scutellum a fine, longitudinal stria extends to transverse stria at basal fourth; disk with a median, oval, moderately shallow depression; surface of disk sculptured like head. *Elytra* nearly three times as long as pronotum (0.93 : 0.32 mm.) and with broadest point at basal third. Sutural stria distinct and complete; opposite

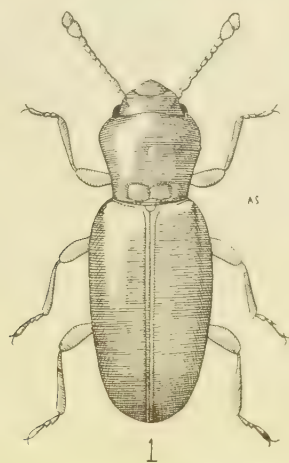


Fig. 1. *Holoparamacus depressus*, Curtis.

scutellum extending laterally so that base is finely margined to, or nearly to, humeri; elsewhere without striae. Surface confusedly punctate like head and pronotum but with punctures often slightly sparser. *Metasternum* distinctly longer than first abdominal sternite (0.27 : 0.19 mm.) and with a feebly impressed, median longitudinal line on caudal half. Abdomen usually with only five visible sternites, occasionally with part of sixth exposed.

♀. Externally similar to ♂ but with antennae 10- instead of 9-segmented and with third segment slightly but distinctly shorter instead of as long as second.

Comparative notes : This species may be readily distinguished from the preceding as follows : (1) antennae 9-segmented in male and 10-segmented in female instead of 11-segmented in both sexes; (2) pronotum with a sublateral longitudinal stria on each side and basal region near hind angle flat, whereas in *H. caularum* there are no sublateral striae and there is a deep depression on basal region near hind angle; and (3) metasternum with median longitudinal line confined to caudal half instead of complete.

Immature stages : Coquerel (1848) has given a very brief description of the larva and pupa and a poor figure of each stage. The larva differs from all other LATHRIDIIDAE in having terminal urogomphi on the ninth abdominal segment. The pupal stage lasts 10 days.

Distribution : Cosmopolitan.

Habits : In dried fungi imported into France from Brazil (Aubé, 1843) ; larvae causing considerable damage by excavating galleries in chocolate bars imported into Madagascar from France (Coquerel, 1848) ; on outside wall of flour-mill in Norfolk and amongst small pieces of decayed wood and bark imported into England from Mexico (Curtis, 1862) ; a true indoor insect found among packing-cases, old boxes, etc., in warehouses and other similar localities in England (Olliff, 1883) ; in flour in Britain (Fowler, 1889) ; probably imported in stored rice and other stored products into Denmark (Belon, 1897) ; and in a ginger jar in Liverpool (Patton, 1931).

Holoparamesus singularis (Beck).

Silvanus singularis, Beck, Beitr. baier. Insektenfauna, **14**, 1817, p. 14, t. 3, f. 15.

♂. Length, 1.0–1.2 mm. Very similar to *H. depressus*, Curtis, but may be distinguished as follows : (1) eyes much smaller and separated by a distance equal to their diameter from base of antennae, whereas in *H. depressus* they are separated by one-half or less than one-half a diameter from base of antennae ; (2) pronotum without a discal depression and without a carina on each side near hind angle ; and (3) metasternum scarcely as long as first abdominal sternite and without a median longitudinal line, whereas in *H. depressus* the metasternum is distinctly longer than first abdominal sternite and has a median longitudinal line on caudal half.

♀. Differs from ♂ in having 10- instead of 9-segmented antennae.

Distribution : Europe, Africa, Canary Is., India, North and Central America.

Habits : On a hot-bed in England (Olliff, 1883) ; under bark, damaging stored rice, in soft earth near hay-stacks, etc. (Belon, 1897) ; and under damp leaves in Germany (Reitter, 1911).

Eufalloides holmesi, Hinton.

Eufalloides holmesi, Hinton, Bull. Ent. Res., **32**, 1941, p. 177.

This species has only recently been described and figured by me, and the description will not be repeated here.

Distribution : Peru.

Habits : In Peru on floors and walls of room in which Nepal barley was stored (Hinton, 1941).

Metophthalmus hispidus, Belon.

Metophthalmus hispidus, Belon, Ann. Soc. ent. Belg., **39**, 1895, p. 86.

Length, 1.3 mm. Body oval ; elytra brownish-black ; head, pronotum, antennae, and legs reddish-brown. Head with sides in front of eyes deeply excavated ; surface feebly rugulose. Eyes moderately small and occupying hind angles of head. Antennae 11-segmented, club 3-segmented with first two segments subquadrate and apical segment as long as combined length of first two. Pronotum transverse ; sides rounded, explanate, and slightly flexed upwards ; with a deep, transverse depression in front of base ; anterior part of disk with a median depression ; longitudinal carinae obtuse but distinct at sides of median depression. Elytra ovate. Each elytron with humeral angle toothed ; with eight rows of large punctures ; and with intervals evenly and feebly convex, not carinate. Elytra with rows of conspicuous setae which have their apices recurved.

Comparative notes : This may be distinguished from all other species of *Metophtalmus* by having rows of conspicuous recurved setae on the elytra.

Distribution : Chile.

Habits : Found in tobacco imported from Chile (Belon, 1895).

Metophtalmus serripennis (Broun) (fig. 2).

Lithostygnus serripennis, Broun, Bull. N. Zealand Inst., 1 (3), 1914, p. 185.

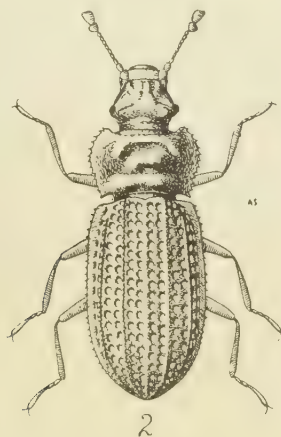


Fig. 2. *Metophtalmus serripennis* (Broun).

Length, 1.1–1.4 mm. ; breadth, 0.41–0.54 mm. Body subparallel-sided and moderately strongly convex ; dorsal surface nearly glabrous. Cuticle strongly shining and reddish-brown ; antennae and legs brownish-testaceous. *Head* with two prominent, median, subparallel carinae which extend to a point opposite base of antennae ; on each side with a fine, very strongly elevated carina which extends transversely from caudal part of eye nearly to caudal part of median carina ; side between eye and base of antenna prominently carinate ; surface rugulose and punctate, the punctures of middle of head being slightly coarser than facets of eyes and more or less contiguous. Eye small (0.04 mm. broad), strongly convex, and separated by two diameters from base of antennae. Antenna 11-segmented ; club 2-segmented. *Pronotum* across broadest point, which is at apical third, broader than long (0.46 : 0.30 mm.) and base broader than apex (0.35 : 0.30 mm.). Shape, impressions, and gibbosities as shown in fig. 2 ; median longitudinal carinae broadly interrupted and broken into a series of tubercles. Surface in basal and apical marginal lines and on anterior half of disk sculptured like middle of head ; surface elsewhere finely rugulose or nearly smooth and only with microscopic punctures. *Elytra* nearly three times as long as pronotum (0.82 : 0.30 mm.) ; at base almost as broad as broadest point of pronotum ; from base to basal fifth widening and thence more or less subparallel to apical third. Humeri often dentate ; lateral margins, like base of pronotum, with a series of fine tubercles or teeth each of which bears a very fine hair. Intervals flat except for third which is strongly carinate from base to near apex and fifth which is equally strongly carinate from basal fifth to slightly nearer apex than third. Each elytron with six rows of deep punctures ; on basal half of disk punctures are round to subquadrate, nearly as large as eyes, nearly twice as broad as intervals, and separated longitudinally by about one-half a diameter. *Metasternum* much shorter

than first abdominal sternite ; without a median longitudinal line ; disk with posterior half strongly declivous caudally so that lowest part is at middle of hind margin ; surface of disk microscopically punctate and shining. Abdomen with middle basal part of first sternite strongly declivous anteriorly ; caudal third with a broad, deep, transverse, sinuate, and complete depression. Sternites 2 to 5 each with a broad, deep, transverse, complete depression near anterior margin ; sternites 2 and 3 with an oval, moderately prominent gibbosity on each side on posterior third near lateral margin ; sternite 5 with middle broadly and shallowly depressed ; sternite 6 usually partly exposed. Surface of sternites strongly shining ; microscopically, sparsely punctate at middle and more coarsely and densely punctate at sides.

Distribution : New Zealand, Britain (imported).

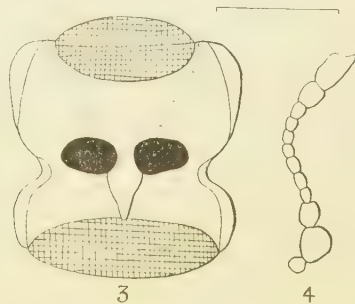
Habits : Found among dead leaves in New Zealand (Broun, 1914). First recorded in England in a wine cellar (Stott, 1928). In straw bottle-envelopes (Stott, 1931) where it probably feeds on fungi developing upon the straw (Blair, 1931). I have seen two specimens collected in a London warehouse.

***Coninomos constrictus* (Gyllenhal) (figs. 3-4).**

Latridius constrictus, Gyll., Ins. Suecica, **4**, 1827, p. 138.

Latridius carinatus, Gyll., Ins. Suecica, **4**, 1827, p. 173.

Lathridius approximatus, Woll., Col. S. Helenae, 1877, p. 52.



Figs. 3-4. *Coninomos constrictus*, (Gyll.) : (3) ventral view of prothorax ; (4) antenna.

♂. Length, 1.2-1.7 mm. Body elongate and subparallel-sided to obovate. Dorsal surface nearly glabrous. Cuticle dark reddish-brown to brownish-testaceous ; antennae and legs paler. Head with a moderately shallow, narrow, median longitudinal depression ; surface coarsely, rugosely punctate, with punctures often twice as coarse as facets of eyes. Eyes convex, large (about 0.11 mm. broad), and separated by slightly less than their diameter from base of antennae ; temples behind eyes slightly shorter than eyes and feebly converging. Antenna (fig. 4) with club 2-segmented, the apical segment being distinctly longer but no broader than basal. Clypeus with anterior margin nearly truncate ; surface with punctures about as coarse as facets of eyes and separated by less than one to nearly one diameter. Labrum with anterior margin feebly rounded. *Pronotum* across broadest point, which is at apical fourth or fifth, as broad as long (0.38 mm.) and base slightly broader than apex (0.32 : 0.30 mm.). Sides very deeply and moderately narrowly sinuate at basal third ; base finely and completely margined, nearly straight. Disk on basal third with a complete transverse impression which is deep at sides and shallow on middle ; middle anterior half of disk with a broad, oval, moderately shallow depression ; from near

base two median, moderately prominent carinae feebly diverge anteriorly and nearly attain anterior margin; from each carina on apical fourth a similar but curved accessory carina extends posteriorly and outwards to basal half, these accessory carinae frequently being very inconspicuous. Surface of disk sculptured like front of head but with rugae often less prominent. *Elytra* nearly three times as long as pronotum (1.1 : 0.38 mm.). Suture interval feebly convex on basal half; interval 3 feebly convex to near apex where it is joined to subcarinate seventh; 5 moderately feebly convex and not extending as far as 3 and 7 towards apex; intervals 2, 4, 6 and 8 flat or nearly so. Striae feebly impressed; stria punctures on basal half of disk deep, round to subquadrate, as broad as or slightly broader than intervals, and separated longitudinally by slightly less than their diameters; between interval 7 and lateral margin of elytra with only two rows of punctures. *Mesosternum* very deeply impressed between middle coxae. *Metasternum* with a deep, broad, median longitudinal line on caudal three-fifths; on each side behind middle coxa with a deep, broad, oval depression from which radiate a number of fine, elevated lines; disk moderately convex on each side and surface with numerous microscopic punctures. Abdomen with all of middle basal region of first sternite very deeply depressed and with a number of fine, elevated lines extending posteriorly from this depression. Surface of sternites densely, microscopically punctate.

♀. Externally similar to ♂.

Comparative notes: From all other species of *Coninomus* dealt with here it may be distinguished by its 2- instead of 3-segmented antennal club.

Distribution: Cosmopolitan.

Habits: In a house on Saint Helena (Wollaston, 1877); under bark, dead leaves, etc. in Britain (Fowler, 1889); under mouldy hay and straw refuse in Germany (Reitter, 1911); in nest of *Lasius fuliginosa* in England (Walker, 1920); in cellars in Finland (Kangas, 1936); and under beech bark in England (Donisthorpe, 1939). I have seen a specimen collected (iii.1940) in a Liverpool warehouse.

***Coninomus bifasciatus*, Reitter.**

Coninomus bifasciatus, Reitt., Mitt. Münch. ent. Ver., **1**, 1877, p. 138.

Lathridius nigromaculatus, Blackb., Trans. Roy. Soc. S. Austral., **10**, 1888, p. 203.

Length, 2.0-2.1 mm. Body elongate, subparallel-sided; dorsal surface more or less glabrous. Cuticle feebly shining and brownish-testaceous; head and pronotum reddish-brown; each elytron with a large, irregularly shaped, blackish patch on basal third and another on apical half, each of these patches sometimes being broken into two or three smaller ones; antennae and legs paler. *Head* coarsely, rugosely punctate and with two longitudinal, distinct rugae on front. Antennal club 3-segmented. *Pronotum* about as broad as long and very slightly broader than head. Disk with median longitudinal carinae indistinct; between carinae on anterior half of disk with a moderately deep, oval depression; surface coarsely and rugosely punctate like front of head. *Elytra* much broader than pronotum; without a distinct depression in front of apical declivity. Intervals feebly, more or less evenly convex with alternate intervals only slightly more convex than others, never carinate. Strial punctures coarse and dense.

Comparative notes: From all other species of *Coninomus* dealt with here which have a 3-segmented antennal club, it may be distinguished by its non-carinate elytral intervals and the absence of a distinct depression on the elytra in front of the apical declivity.

Distribution: Australia.

Habits: In stored Australian tobacco (Belon, 1895).

Coninomus nodifer (Westwood) (figs. 5-7).

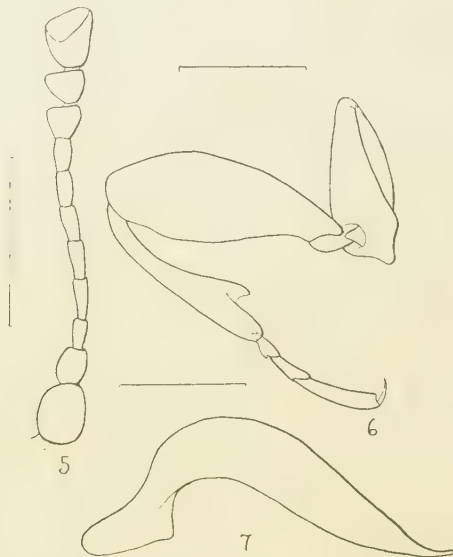
Lathridius nodifer, Westw., Introd. Mod. Classif. Ins., **1**, 1839, p. 155, f. 13, 23.

Lathridius antipodum, White, Voy. Erebus & Terror, Ins., 1844, p. 18.

Lathridius nodulosus, Mots., Bull. Moscou, **29** (3), 1866, p. 261, pl. 6, f. 7.

Lathridius sculpturatus, Broun, Man. N. Zeal. Col., **1**, 1888, p. 233.

Lathridius humilis, Rey, Echange, 1889, p. 54.



Figs. 5-7. *Coninomus nodifer*, (Westw.) ♂: (5) antenna; (6) hind leg; (7) left lateral view of genitalia.

♂. Length, 1.5-2.1 mm. Body moderately elongate, subparallel-sided, moderately strongly convex; dorsal surface glabrous or nearly so. Cuticle shining and pale brownish-testaceous (freshly emerged specimens) to dark brownish-black or black; nearly black specimens with antennae and legs paler, reddish-brown; mature specimens with a characteristic white deposit on sides of pronotum and on many parts of ventral surface. Head with a moderately broad and shallow, median depression extending from base to anterior margin; surface coarsely and rugosely punctate, the punctures usually being distinctly larger than facets of eyes and confluent to separated by one diameter. Eyes nearly round, strongly convex, 0.11 mm. broad, and separated by less than their diameters from base of antennae; temples behind eyes feebly converging caudally, nearly as long (3.5:4) as eyes. Antenna (fig. 5) slender, club 3-segmented, and segment 8 about twice as long as broad. Clypeus with anterior margin truncate; surface more finely and less rugosely punctate than head. Labrum with anterior margin feebly, broadly rounded; surface not rugose and only finely punctate. Pronotum across broadest point, which is at apical fifth or sixth, not quite as broad as long (0.43:0.46 mm.) and base broader than apex (0.39:0.32 mm.). Sides nearly straight on basal fourth, very deeply and rather broadly constricted at basal third, and arcuate on apical half; apex finely, deeply margined except where marginal line is interrupted by longitudinal carinae; base

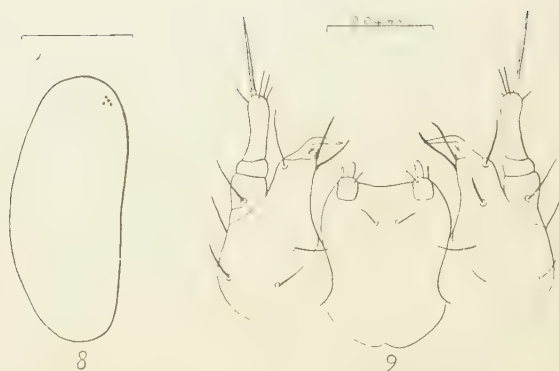
nearly truncate and finely, moderately deeply, and completely margined. Pronotum with a moderately broad and deep, complete, transverse impression on basal third; median longitudinal carinae prominent and extending from about basal seventh to anterior margin; on apical fourth of disk carinae are moderately arcuate outwards; from outer side of apical fourth of each carina an indistinct carina extends caudally and outwards for a short distance; apical half moderately shallowly depressed between median carinae. Surface of most of apical half sculptured like front of head; surface of sides of apical half and most of basal half nearly smooth, without coarse punctures. *Elytra* three times as long as pronotum (1.37:0.46 mm.) and base distinctly broader than broadest point of pronotum; from base becoming broader caudally to broadest point which is just beyond basal third. *Elytra* with a large, transverse, moderately shallow depression on basal third extending on each side to interval 5; on middle from interval 5 to lateral margin with a large, shallow, feebly oblique depression; disk immediately in front of apical declivity with a large and distinct but shallow depression. Each elytron with sutural interval moderately elevated from base to apex (in some specimens it is nearly flat from basal third to apical fourth); interval 3 carinate on basal fourth and feebly convex (sometimes flat) elsewhere except that on apical third it forms a very prominent, oblong gibbosity; interval 5 carinate from base (where it is often only feebly carinate) to apical fifth and most prominent near apex; 7 prominently carinate from base to apical third and from here feebly convex or flat to near apex; intervals 2, 4, 6 and 8 flat or very feebly convex. Each elytron with eight punctate striae; stria punctures on basal half of disk deep, round to subquadrate, as broad as to one-third broader than intervals, and separated longitudinally by two-thirds of one to one diameter. *Mesosternum* very deeply depressed between middle coxae. *Metasternum* with median longitudinal line present on caudal three-fifths; on each side behind middle coxa with a deep, broad, oval depression from which radiate a number of fine, elevated lines; disk moderately convex on each side and on each side of middle near caudal margin with a large, prominent, setose tubercle; surface of disk finely, moderately sparsely punctate. Abdomen with all of middle of first sternite between hind coxae deeply depressed and at bottom on each side of this depression with a large, oval, very deep depression. Surface of sternites punctate similarly to metasternal disk. Sixth sternite sometimes partly visible. *Legs* with ventral side of front trochanters finely carinate. Front and middle tibia with a fine, short spine or tooth on inner apex; hind tibia with a prominent tooth on inner side at apical fourth (fig. 6).

♀. Differs from ♂ as follows: (1) caudal part of metasternal disk without tubercles; (2) front and middle tibia without a fine tooth on inner apex; and (3) hind tibia more slender and without a tooth.

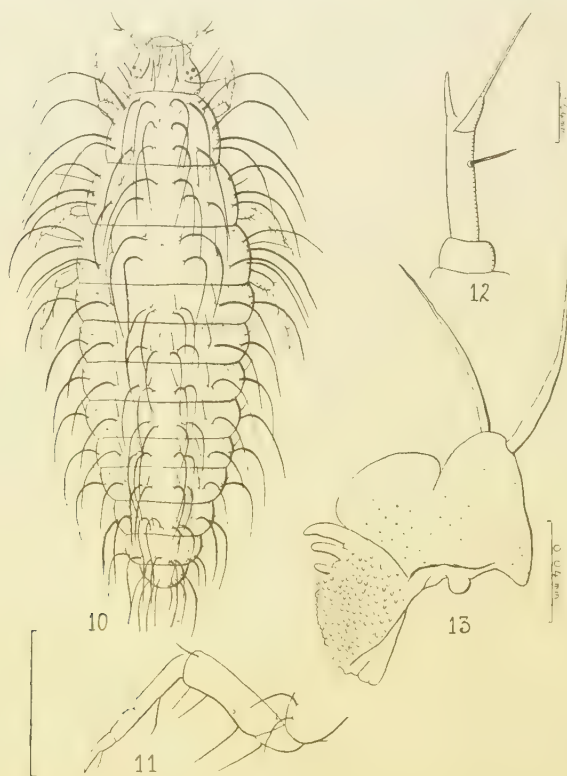
Comparative notes: From all other species of the genus *Coninomus* it may be distinguished by having an elongate and very prominent tubercle on third interval at apical third. The male of no other species has large metasternal tubercles or toothed hind tibiae.

Egg (fig. 8): Length, 0.32-0.48 mm.; breadth, 0.16-0.20 mm. Oblong oval with head end slightly broader and ventral side feebly and very broadly sinuate. Surface not sculptured and shining; colour whitish-opalescent.

Mature larva (figs. 9-13): Length, 2.4 mm.; breadth (across broadest point which is near middle of first abdominal segment), 0.73 mm. Body subcylindrical and parallel-sided. Cuticle white to whitish-testaceous; head pale brownish testaceous with a median longitudinal and two oblique lateral pale bands. *Head* with shape and setae approximately as shown in fig. 10; on each side with three ocelli arranged in a transverse row and one slightly caudal and more or less opposite middle one of transverse row. *Antenna* (fig. 12) as figured. *Mandibles* (fig. 13) of both sides more or less similar; each with a large, very feebly sclerotised apical part from the outer apex of which arise two very long and stout setae; basal part more strongly sclerotised and



Figs. 8-9. *Coninomus nodifer* (Westw.): (8) egg; (9) ventral view of maxilla and labium of third instar larva.



Figs. 10-13. *Coninomus nodifer* (Westw.): (10) dorsal view of mature larva; (11) anterior view of right front leg of same; (12) dorso-lateral view of left antenna; (13) ventral view of left mandible.

with a large ventral grinding surface ; inner side near base also with a grinding surface and middle on inner side with three prominent, heavily sclerotised teeth. Maxilla and labium with palpi and setae as shown in fig. 9. *Tergites* of thorax and abdomen with numerous long, curved, moderately stout setae as shown in fig. 10. *Sternites* of abdomen each with a transverse row of about six setae which are much shorter, more slender, and much less strongly curved than those of tergites. *Legs* all similar in shape and chaetotaxy to front leg (fig. 11), but middle pair slightly longer and third pair longest.

Second instar : Slightly smaller but otherwise similar to third instar.

First instar : 0.49 mm. long and 0.19 mm. broad when first hatched. Differs from second and third instar larvae as follows : (1) head distinctly broader instead of narrower than thorax and basal abdominal segments ; (2) antenna with accessory spine as long instead of distinctly shorter than second segment ; (3) setae of dorsal surface longer in proportion to total length of larva ; and (4) tarsus very nearly as long instead of less than half as long as tibia.

Comparative notes : From all other known larvae of the LATHRIDIIDAE it may be readily distinguished by the structure of the mandibles and the unique arrangement of the long, curved setae of the dorsal surface. The larva of no other species of *Coninomus* has been described.

♂. *Pupa* : Length, 1.6 mm. ; breadth (across first abdominal segment and including elytra), 0.82 mm. Cuticle whitish ; eyes reddish in nearly mature specimens ; setae very long, moderately stout, more or less curved, pale testaceous, and each with a small knob at apex. *Head* completely concealed from above by pronotum. Surface with five setae on each side as follows : one adjacent to inner margin of posterior third of eye ; one slightly caudal to eye and slightly nearer to middle of front than eye ; and three forming a longitudinal row near middle which extends from vertex to a point opposite middle of eye. Antenna extending caudally and outwards and nearly attaining knee of middle leg. *Pronotum* shaped much as in adult but with transverse impression on basal third and median longitudinal carinae less distinct. Apex with three long setae on each side and a shorter and nearly ventral seta between second seta and that of apical angle ; slightly behind median seta of anterior margin with one long and one distinctly shorter seta, and still more caudal but behind second seta of anterior margin with a single long seta. Each lateral margin with a long seta on apical fourth and another on basal third. Base with a long seta on each side on basal angle and one near middle which is slightly anterior to basal margin. *Mesonotum* with a seta on each side of middle near anterior margin and an extreme lateral one on caudal third ; elytra extending caudally and ventrally to posterior margin of second abdominal sternite ; third interval conspicuously gibbous at apical third and fifth slightly less strongly gibbous at apical fourth ; on third interval at about basal sixth with a large seta and with two similar setae on fifth interval at about basal sixth. *Metanotum* on each side with three long setae, two near middle on anterior fourth and one near side on caudal two-fifths ; wings extending caudally and ventrally to posterior margin of third abdominal sternite. Abdominal tergites on each side with a transverse row of three long setae on caudal third ; opposite median seta on anterior fourth with a much finer and shorter seta ; opposite third (most lateral) seta with a much finer and shorter seta ; setae decrease in size posteriorly so that on tergites 6 and 7 they are short and rather indistinct ; tergites 8 and 9 without setae (or at any rate not visible at $\times 75$) ; segment 9 with two stout, more or less parallel urogomphi which are about half as long again as ninth tergite and each is clubbed at apex. Pleurites of first seven segments each with one long and one distinctly shorter seta near caudal margin. *Metasternum* with a gibbosity on each side of middle near caudal margin. Abdomen with a single long seta on each side on second, third, and fourth sternites ; elsewhere with only an occasional short and indistinct seta ; last larval skin always remains

attached to pupa and conceals last two or three segments of abdomen. *Legs* each with three long setae on or near knee. Front pair extend to middle of metasternal disk and at apex are separated by tarsal length. Middle pair extend to basal fourth of first abdominal sternite and are as widely separated at apex as front pair. Hind pair extend nearly to caudal margin of second abdominal sternite and at apex are separated by less than half tarsal length; tibia with a gibbosity on inner side near apex.

♀. *Pupa*: Differs from ♂ in the absence of gibbosities on metasternal disk and hind tibiae.

Distribution: Cosmopolitan.

Habits: Larvae commonly found on mouldy wood in France, and have been bred in partly fermented rose buds which were attacked by a fungus, *Trichosporium roseum* (Perris, 1877); adults in vegetable refuse, moss, woodstacks, faggots, etc. in Britain (Fowler, 1899); in nests of *Bombus lapidarius* and *Vespa vulgaris* in England (Morley, 1899); under mouldy pine bark in Germany (Reitter, 1911); in haystack refuse and in a house cellar in Britain (Carr, 1916); and among debris of wall-paper and colour-wash in a kitchen in Britain (Wallace, 1921). I have taken large numbers in all stages on mould under linoleum in the British Museum (N. H.). I have seen two specimens collected (26.v.1938) on the walls of a London warehouse.

This species has been successfully reared by me on cultures of "*Penicillium glaucum*" and *Mucor Mucedo*, L., growing on bread and cheese kept in petri dishes. The eggs are laid singly on the surface of the bread or cheese, and the female makes no attempt to conceal them. At an average temperature of $60^{\circ}\text{F} \pm 2$ the eggs hatch in five to seven days. The larvae, like the adults, feed exclusively on the spores, conidia, and hyphae of the moulds. First stage larvae moult after six days at $60^{\circ}\text{F} \pm 2$, and second stage larvae kept at the same temperature also took six days to moult. Third stage larvae kept at $68^{\circ}\text{F} \pm 1$ fed for five or six days and then stopped feeding and attached themselves to the substratum by means of an anal secretion. They remained in this resting stage for two or three days and then pupated. The pupal period lasted three to four days at $68^{\circ}\text{F} \pm 1$. The duration of the life-cycle from the time the egg is laid to the time the adult emerges from the pupa varies from 27 to 32 days. When the adult first emerges from the pupa the elytra are more or less white and the rest of the body is very pale brownish-testaceous. After about seven to ten days the adult is the normal dark brown or nearly black colour. In the specimens kept by me the white border of the pronotum does not begin to be secreted until the adult is five to seven days old.

***Coninomus subfasciatus*, Reitter.**

Coninomus subfasciatus, Reitt., Verh. zool.-bot. Ges. Wien, **27**, 1877, p. 183.

A full description of this species has only recently (Hinton, 1941) been given in the pages of this journal, and there is no need to repeat that description here.

Distribution: Chile, Peru.

Habits: In Peru on walls and floor of a room used to store Nepal barley (Hinton, 1941).

***Lathridius lardarius* (De Geer) (fig. 14).**

Tenebrio lardarius, DeG., Mem. Ins., **5**, 1775, p. 45, pl. 2, figs. 25-31.

♂. Length, 2.3-2.8 mm. Body obovate, moderately strongly convex; dorsal surface glabrous or nearly so. Cuticle shining and reddish-brown. *Head* densely and very coarsely, rugosely punctate, the punctures often twice as coarse as facets of eyes and confluent to separated by one-half a diameter. Eyes nearly round, strongly

convex, 0.13 mm. broad, and separated from base of antennae by four-fifths their diameter; temples behind eyes converging caudally, less than half as long as eyes, and caudal margin moderately dentate. Antenna with club 3-segmented and first segment of club twice as long as broad, second (10th) about as long as broad, and apical one-half longer than broad. Clypeus with anterior margin truncate; surface not rugose and only finely punctate. Labrum with anterior margin feebly, broadly rounded and surface microscopically punctate like clypeus. *Pronotum* across broadest point, which is at base, broader than long (0.54 : 0.46 mm.) and base broader than apex (0.54 : 0.46 mm.). Sides very broadly and moderately shallowly sinuate on apical two-fifths. Apex with marginal line narrow, moderately shallow, and interrupted on each side of middle by median carinae; apical angles rounded, feebly dilated, and distinctly produced. Base feebly rounded, nearly truncate, and with a moderately deep and broad, complete marginal line. Pronotum with two median longitudinal carinae extending from near base to near apex which are moderately prominent on basal half and broader and less distinct on apical half; on basal third with a long, shallow, complete, transverse impression; surface coarsely



Fig. 14. *Lathridius lardarius* (DeG.) (after Fall).

rugose and punctate like head. *Elytra* four times as long as pronotum (1.9 : 0.46 mm.), base much broader than broadest point of pronotum, and from base feebly broadened to broadest point at basal two-fifths; elytra strongly narrowed from near middle to the produced apex which extends beyond abdomen; apices narrowly rounded and strongly dehiscent. Humeri broadly and prominently gibbous. Intervals flat or nearly so except for third and seventh which are feebly convex near base. Each elytron with eight feebly impressed striae; striae punctures on basal half of disk deep, round to rectangular, one-half to two-thirds as coarse as intervals, and separated longitudinally by less than one to one diameter; towards apex punctures become much finer and sparser; on middle sides, particularly in sixth and seventh striae, punctures are often twice as long as broad. *Mesosternum* deeply impressed between coxae. *Metasternum* with median longitudinal line broad, moderately shallow, and present on caudal three-fifths; on each side behind middle coxa with an oval, moderately shallow depression from which radiate a number of long, fine, elevated lines; disk moderately feebly convex on each side on basal third; surface densely, microscopically alutaceous and with fine punctures. Abdomen with first sternite not depressed between coxae; apical margin of fifth sternite shallowly, arcuately emarginate for its entire breadth. Surface of sternites densely, microscopically alutaceous like metasternal disk. *Legs* with base of ventral side of front femora with a small but distinct, acute tooth. Front tibia moderately curved outwards on apical third; with a distinct, small, acute tooth on inner side very near apex; and with a number of fine, acute teeth on inner side of apical

half. Middle tibia similar to front but with fine teeth not so distinct. Hind tibia similar to middle but not distinctly curved.

♀. Externally similar to ♂ except in the following particulars: (1) front femora without a basal tooth; (2) front and middle tibiae not curved; and (3) front, middle, and hind tibiae without a prominent tubercle near inner apex or much finer tubercles on apical half.

Comparative notes: The strongly produced apices of the elytra and the secondary sexual characters of the male will serve to distinguish it from all other species of *Lathridius*.

Immature stages: The larvae and pupae have been described by De Geer (1781), but his descriptions are too short and his figures too inaccurate to be of much use. The pupal stage lasts one month.

Distribution: Europe, N. America.

Habits: Larvae found on a mouldy dried pig's bladder (De Geer, 1781); and adults in hot-beds, vegetable refuse, moss, etc. in Britain (Fowler, 1889).

***Lathridius bergrothi*, Reitter (fig. 15).**

Lathridius bergrothi, Reitt., Verh. zool-bot. Ges. Wien, **30**, 1880, p. 53.

Lathridius microps, Ericson, Ent. Tidskr., **17**, 1896, p. 266.

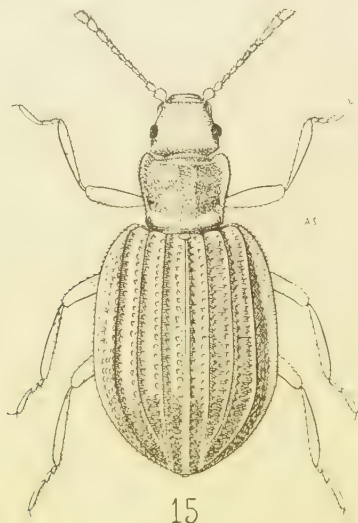


Fig. 15. *Lathridius bergrothi*, Reitt.

♂. Length, 1.8–2.2 mm. Body obovate, moderately strongly convex; dorsal surface nearly glabrous, only sparsely clothed with short, microscopic hairs. Cuticle moderately shining and reddish-brown; antennae and legs slightly paler. Head coarsely, rugosely, and often confluent punctate with punctures which are half again to twice as coarse as facets of eyes. Eyes nearly round, moderately small (0.08 mm. broad), hemispherical, and separated by a distance equal to their own diameters from base of antennae; temples feebly converging caudally, nearly parallel, slightly shorter than eyes, and caudal margin, when seen from above, feebly dentate. Antenna with club 3-segmented. Clypeus with anterior margin shallowly, arcuately emarginate for

its entire breadth ; surface more sparsely, much less rugosely, and more finely punctate than head. Labrum with anterior margin broadly rounded and surface only microscopically punctate. *Pronotum* across broadest point, which is at apical sixth, broader than long (0.46 : 0.38 mm.) and base as broad as apex (0.38 mm.). Sides diverging anteriorly, very broadly and moderately shallowly sinuate on most of basal half ; sides narrowly dilated and moderately strongly flexed upwards. Apex with a shallow, complete marginal line ; apical angles broadly rounded and moderately produced forwards. Base nearly truncate ; marginal line broad and moderately deep. Disk with median carinae extending from basal to apical seventh, prominent on basal half, and indistinct on apical half ; apical half of disk between carinae feebly depressed ; on basal third with a long, nearly complete, transverse depression. Surface sculptured like front of head but near sides and base with punctures finer and surface much smoother. *Elytra* more than three times as long as pronotum (1.4 : 0.38 mm.), base only slightly broader than broadest point of pronotum, and from base broadening caudally to broadest point at about apical two-fifths ; feebly depressed on each side of suture immediately before apical declivity. Humeri prominent but not gibbous. Each elytron with sutural interval feebly raised ; interval 3 carinate on basal third and then moderately convex to near apex ; 5 and 7 carinate nearly to apex. Striae scarcely noticeably impressed ; each elytron with eight rows of punctures on basal two-fifths and 10 rows on apical three-fifths ; between seventh interval and lateral margin with two rows of punctures on basal two-fifths and four rows of punctures between apical three-fifths and apical fifth ; on basal half of disk with punctures moderately deep, round to subquadrate, as broad as intervals, and separated longitudinally by one or slightly less than one diameter. *Mesosternum* deeply impressed between coxae. *Metasternum* with median longitudinal line moderately deep and present on caudal half ; on each side behind middle coxa with a moderately deep and broad, oval depression from which radiate a number of long, fine, elevated lines ; disk moderately strongly convex on each side of middle. Abdomen with first sternite not distinctly depressed between coxae ; surface of sternites only microscopically punctate.

♀. Externally similar to ♂.

Comparative notes : *L. bergrothi* may be distinguished from all allied species by having two rows of punctures on basal and four rows on apical part of elytra between seventh interval and lateral margin.

Immature stages : The larvae and pupae have been described but not illustrated by Poppius (1912). A number of adults found in a cellar in Finland were placed by him (25.vii) in a jar containing mouldy bread. By 20th August larvae were present. The larvae, which were negatively phototropic, lived under the bread. Larvae pupated in the beginning of September, and on the 20th of the same month recently emerged adults were found. Some of the adults placed in the jar on 25th July were still alive by 20th September.

Distribution : Europe, Greenland.

Habits : In faggots in France and in moulds in Germany (Belon, 1897) ; on dried burdock (*Arctium*) in a herbarium in Britain (Thornley, 1901) ; in an old hat in France (Giard, 1902) ; in a house and in a kitchen in Germany (Hubenthal, 1902) ; in a London granary (Chitty, 1904) ; in a cellar in Britain (Bagnall, 1905) ; in a London granary (Donisthorpe, 1905) ; in a wine cellar in Britain (Joy, 1906) ; in a cellar in Britain (Walker, 1907) ; abundant on pair of old boots in cellar in Britain (Sharp, 1908) ; larvae very common on walls of a room, and in another newly decorated house in Germany larvae, pupae, and adults were found on damp walls (Lühe, 1908) ; in large numbers in empty house behind pictures, by windows, etc. in Germany (Lühe, 1909) ; abundant in cellar in Potsdam (Wanach, 1909) ; in houses and cellars in Germany (Reitter, 1911) ; in a London warehouse (Newbery, 1912) ; in samples

of damaged flour in the U.S.S.R. (Portchinsky, 1913) ; among debris of wall-paper and colour-wash in kitchen in Britain (Wallace, 1921) ; on window of drug store in Germany (van Emden, 1925) ; frequently a house pest in Germany (Zacher, 1927) ; on walls of a London warehouse (Richard & Herford, 1930) ; in boxes of Eastern dates in a Dutch warehouse (Everts in Patton, 1931) ; on mouldy wall-paper in a house in Germany (Herold, 1933) ; in cellars in Finland (Kangas, 1936) ; and on walls of warehouse in Britain (Hayhurst, 1937). I have seen two specimens found in raw cocoa in Birmingham and a number of specimens taken in several different warehouses in London.

Enicmus minutus (Linnaeus) (fig. 16).

Tenebrio minutus, L., Syst. Nat., **12**, 1767, p. 675.

Lathridius porcatus, Herbst in Jablonsky, Nat. Ins. (Käf.), **5**, 1793, p. 6, pl. 44, f. 4.

Lathridius anthracinus, Mann., in Germar, Zeit. Ent., **5**, 1844, p. 97.

Lathridius assimilis, Mann., t.c., p. 98.

Lathridius scitus, Mann., t.c., p. 99.

Lathridius gemellatus, Mann., t.c., p. 100.

Lathridius minutissimus, Mots., Etud. Ent., **6**, 1857, p. 24.

Lathridius opacipennis, Woll., Cat. Col. Canar., 1864, p. 151.

Enicmus lederi, Reitt., Stett. Ent. Zeit., **36**, 1875, p. 327.

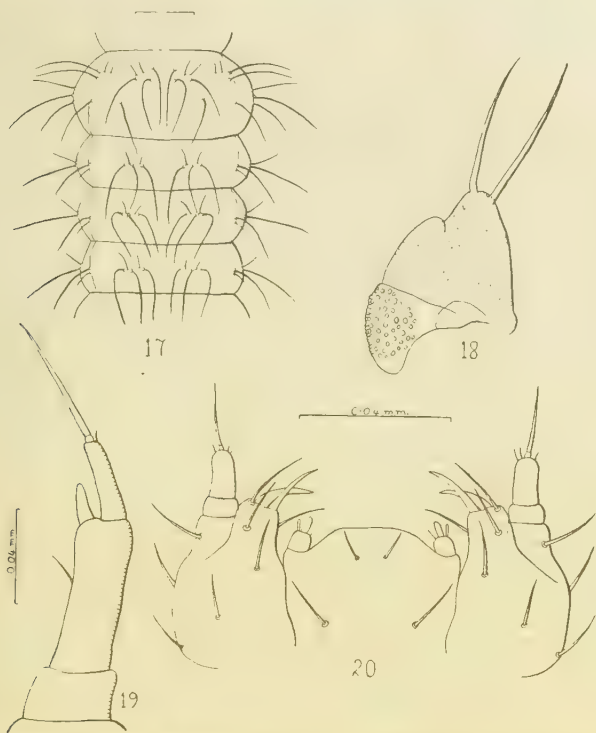


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Fig. 16. *Enicmus minutus* (Linn.).

♂. Length, 1.2-2.4 mm. Body subparallel to obovate and moderately strongly convex ; dorsal surface glabrous or at most with sparse, microscopic hairs. Cuticle moderately shining and moderately pale reddish-brown to black ; when black, with antennae and legs reddish-brown. *Head* with a moderately shallow and broad median channel extending from base to anterior margin ; surface rugose and with deep punctures which are about one-third coarser than facets of eyes and are confluent to separated by half a diameter. Eyes nearly round, large (0.11 mm.), strongly convex, and separated by a distance equal to nearly two-thirds their diameter from base of antennae ; temples parallel and about half as long as eyes. Antenna with club 3-segmented ; tenth segment about as long as broad and all other segments except first distinctly longer than broad. Clypeus with anterior margin truncate or nearly so ; surface similarly but more finely sculptured than head. Labrum with anterior

margin broadly, shallowly, and arcuately emarginate on middle; surface not rugose and only very finely punctate. *Pronotum* across broadest point, which is at apical sixth or seventh, broader than long (0.47:0.35 mm.) and base as broad as apex (0.38 mm.). Sides diverging anteriorly and very shallowly and broadly sinuate at about middle; feebly dilated, particularly anteriorly, and with margin strongly flexed upwards. Apex with marginal line very shallow and indistinct, scarcely noticeable at middle; apical angles strongly rounded and moderately produced forwards. Base feebly rounded, nearly truncate; marginal line complete and rather shallow. Disk with a broad, complete, moderately deep, transverse impression on basal fourth or third; apical half of disk with a broad, oval, moderately deep depression; a short, indistinct, longitudinal carina on each side of middle crossing basal transverse depression. Surface sculptured like front of head but slightly more



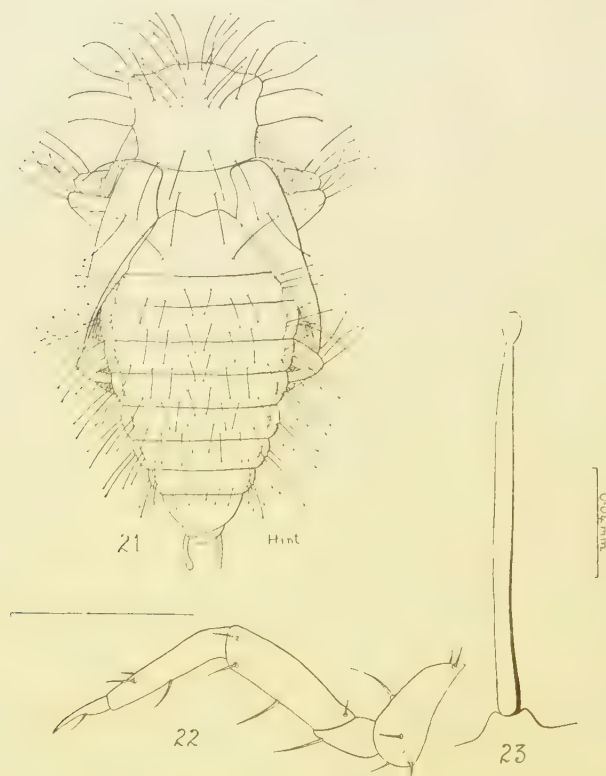
Figs. 17-20. Larva of *Eniemus minutus* (Linn.): (17) metathorax and first three abdominal segments; (18) ventro-lateral view of left mandible; (19) dorsal view of right antenna; (20) ventral view of maxilla and labium.

coarsely so; near base on each side with a much smoother and more finely, sparsely punctate area. *Elytra* slightly more than three times as long as pronotum (1.20:0.35 mm.), base about as broad as broadest point of pronotum, and from base broadening caudally to broadest point which is at about basal third; elytra broadly rounded at apex. Alternate intervals usually feebly convex, more elevated than even intervals; 7 always, 5 occasionally, and 3 only rarely subcarinate on basal half. Each elytron

with eight feebly to moderately impressed punctate striae; strial punctures on basal half of disk very deep, round to quadrate, as broad to two-thirds as broad as intervals, and separated longitudinally by three-fifths to one diameter. *Mesos sternum* on caudal third with a large, oval, very deep depression on each side adjacent to coxa. *Metasternum* with median longitudinal line fine, shallow, and present on caudal half; on each side behind middle coxa with a large, deep, oval depression from which radiate a number of moderately long, rather stout, elevated lines; disk moderately feebly convex on each side; surface only feebly shining and with deep, round to oval punctures about as coarse as facets of eyes and confluent to separated by two to three diameters. Abdomen with most of first sternite except extreme middle base punctate like metasternal disk but more densely and slightly more finely so; surface between punctures densely, microscopically punctate; surface of other sternites for the most part with only dense microscopic punctures.

♀. Externally similar to ♂.

Variations: Aside from the variations in size and colour already mentioned, this species varies strikingly in the punctation of the metasternum and abdominal sternites. Specimens are frequently met with which have the metasternum more densely and the first abdominal sternite less densely punctate than in the specimen described above. The interspaces between the coarse punctures of the metasternal disk and the first abdominal sternite are sometimes only sparsely instead of densely microscopically



Figs. 21-23. *Enicmus minutus* (Linn.): (21) dorsal view of pupa; (22) anterior view of right front leg of third instar larva; (23) enlarged view of pronotal seta of pupa.

punctate ; and the surface of the four apical abdominal sternites is often nearly smooth and rather strongly shining. A few specimens that have been examined have the surface of the first abdominal sternite longitudinally rugose as well as densely punctate.

Egg : Length, 0.47 mm. ; breadth, 0.18 mm. Broadly oblong oval ; ventral side feebly concave. Surface shining and not sculptured ; colour whitish-opalescent.

Larva (figs. 17-20, 22) : Kyber (1817) and Perris (1852) have described the immature stages of this species, but their descriptions and figures contain so many inaccuracies—Perris, for example, describes and figures apical teeth on the mandible—that they are no use for identifying the species. The descriptions and figures given here are based on material bred by me.

Mature larva : Length, 2.20 mm. ; breadth (across middle of first abdominal segment), 0.60 mm. General proportions and colour similar to that of *C. nodifer*, from which it may be easily distinguished as follows : (1) mandible (fig. 18) without prominent median teeth on inner side ; and (2) setae of dorsal surface relatively much shorter, more slender, less strongly curved, more numerous, and those of thoracic and abdominal tergites forming a different pattern (*cf.* figs. 10 and 17). Mesonotum and pronotum setose like metanotum (fig. 17), but lateral setae of pronotum somewhat differently arranged. Abdomen with dorsal setae of all segments similar to those shown for first three segments (fig. 17), but with median setae of apical tergites, particularly on tergites 8 and 9, very much nearer to or actually on caudal margin.

Earlier instars : The second instar is smaller but otherwise apparently identical to third. The first instar may be distinguished from second and third by its proportionally broader head and the tarsus which is nearly as long instead of less than half as long as tibia.

♂. *Pupa* (figs. 21, 23) : Length, 1.53 mm. ; breadth (across third abdominal segment including elytra), 0.76 mm. Cuticle whitish ; eyes reddish after first few days ; setae (fig. 23) long, slender, more or less curved, pale testaceous, and each with a small knob at apex. *Head* completely concealed from above by pronotum or only with vertex visible. Surface with six setae on each side as follows : one near middle of mesal margin of eye ; one near caudal mesal margin of eye ; one slightly more caudal and in line with the latter ; and three forming a longitudinal row slightly nearer middle of head, the most anterior of these being opposite caudal margin of eye. Antenna extending caudally and outwards to femora of middle leg. Dorsal surface with shape and setae as shown in fig. 21 ; elytra extending caudally and ventrally nearly to posterior margin of second abdominal sternite ; on third interval on about basal fourth or fifth with a long seta ; alternate intervals feebly convex. Wings extending caudally and ventrally to middle of third abdominal sternite. Abdomen with apical two or three segments always clothed with cuticle of third instar larva ; first five sternites with a seta on each side on caudal third at about two-thirds of distance from middle and each also with a longer, extreme lateral seta. *Legs* with three long setae on or near each knee (fig. 21). Front pair extend to middle of metasternal disk and at apex are separated by a distance equal to two-thirds of tarsal length. Middle pair extend slightly beyond caudal margin of metasternum and at apex are separated as widely as front pair. Hind pair extend to caudal margin of second abdominal sternite and at apex are separated by slightly less than half of tarsal length, but in a few specimens they are nearly contiguous.

2. *Pupa* : Externally similar to ♂ but with two oval, median, moderately prominent buds caudal to but near posterior margin of sixth visible sternite.

Comparative notes : This is very similar to the pupa of *C. nodifer*, but may be distinguished as follows : (1) pronotum with 12 instead of 6 (not counting those of margins) setae on anterior half of disk ; (2) mesonotum with two instead of four

setae ; (3) metanotum with two instead of six setae ; (4) elytra without gibbosities and fifth interval without setae ; and (5) male without gibbosities on metasternal disk or on hind tibiae.

Distribution : Cosmopolitan.

Habits : In Germany on *Mucor Mucedo*, L., growing on a pig's bladder, on mouldy radishes, on mouldy coffee, etc., and in houses, cellars, stables, etc. (Kyber, 1817) ; in nests of wasps and ants in France (Perris, 1852) ; on damp paper and old wood in houses in Britain (Curtis, 1862) ; in France on mouldy materials such as skins of grapes and on wine dregs fermenting on borders of wine casks (Perris, 1877) ; in Britain in haystack and other refuse, moss, dung-heaps, wood-stacks, etc. (Fowler, 1889) ; in a London granary (Donisthorpe, 1897) ; among moulds and in houses (Belon, 1897) ; in nests of *Bombus lapidarius* and *Vespa vulgaris* in Britain (Morley, 1899) ; on dried burdock (*Arctium*) in a herbarium in Britain (Thornley, 1901) ; in a damp kitchen in Germany (Hubenthal, 1902) ; in a wine cellar in Britain (Joy, 1906) ; in samples of damaged flour in the U.S.S.R. (Portchinsky, 1913) ; adults and larvae in fungi under boards, in casks in cellars, in fungi on trees, in cocoons of *Coleophora siccifolia*, and in a stork's nest (Schaufuss, 1916) ; among debris of wall-paper and colour-wash in a kitchen in Britain (Wallace, 1921) ; in Finland in cellars, in nests of *Scitropterus volans*, on walls of newly built houses, and on fungi on trees, e.g., *Daldinia concentrica* on birch and *Bjerkandera borealis* on pine (Saalas, 1923) ; on damp walls of a London warehouse (Richards & Herford, 1930) ; in damp bedroom of a house in England (Blair, 1933) ; in cellars in Finland (Kangas, 1936) ; in wheat, barley, and on warehouse walls in England (Hayhurst, 1937) ; under bark, in bird nests, manure-heaps, fungi, etc. in England (Donisthorpe, 1939) ; and in stored wheat in a mill in Egypt (Zacher, 1940). I have found all stages in several London houses feeding in mouldy bread and also in large numbers under the linoleum of various parts of the British Museum (N. H.). I have seen seven specimens which were taken on barrels, etc., in a London wine store.

This species has been successfully reared by me on cultures of "*Penicillium glaucum*" growing on bread kept in petri dishes. The cultures were kept at a mean temperature of 62-65°F. The larvae and adults ate the conidia as well as the hyphae of the *Penicillium*. Both stages would also readily eat *Mucor Mucedo*, L. The eggs are laid singly under or on the surface of the bread and hatch in five to six days. The first instar lasts four or five days and the second instar a similar period. The third instar larvae feed for three or four days and then stop feeding for two or three days before pupating. After they stop feeding they wander about for a short time apparently looking for a suitable place in which to pupate, and when one is found the caudal tip of the larva is rather firmly fixed to the substratum by some sort of anal secretion. Pupation takes place in crevices in the partly dried bread or in exposed places on the bottom or sides of the glass dish. The pupal period is six to seven days. Kyber (*l. c.*) says the duration of the pupal stage is 14 days and Perris (1852) 15 days. These differences in the duration of the pupal period are undoubtedly due to differences in temperature. The life-cycle—from the time the egg was laid to the time the adult emerged from the pupa—varied from 24 to 30 days.

***Enicmus protensicollis* (Mannerheim) (fig. 24).**

Latridius protensicollis, Mann., Bull. Soc. Imp. Nat. Moscou, **16** (2), 1843, p. 299.

Latridius quadricollis, Mann., *l. c.*

Latridius sobrinus, Mann., *op. cit.*, **25** (1), 1852, p. 362.

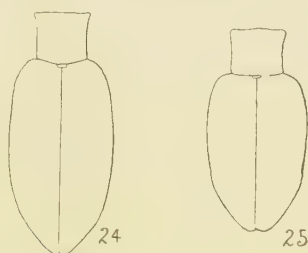
♂. Length, 2.4-2.6 mm. Body elongate, subparallel-sided, feebly convex. Cuticle shining and varying from testaceous to brown ; pronotum usually slightly darker than elytra ; basal half of elytra frequently with a darker sutural strip. Head about as long as broad and with a median longitudinal depression ; surface rugosely

punctate. Eyes moderately large and strongly convex; temples slightly shorter than eyes and visibly diverging caudally. Antenna with club 3-segmented; tenth segment about as broad as long and all others except first distinctly longer than broad. *Pronotum* slightly broader than head, about as long as broad or very nearly so, apical angles lobed, and sides nearly parallel behind apical angles; median channel shallow, its sides feebly interrupting sub-basal transverse depression, which is well defined throughout but deeper at sides; pronotum with a depression very near front angles and usually with a smaller depression on either side of median channel at or just before middle. Surface densely rugosely punctate. *Elytra* about twice as broad as pronotum and about twice as long as broad; sides feebly arcuate and subparallel to beyond middle, thence arcuately narrowed to apex which is slightly produced. Intervals nearly flat or slightly convex, the convexity increasing somewhat towards sides. Striae feebly impressed on disk, more noticeably impressed on sides; stria punctures on disk nearly as broad as intervals, but towards sides narrower than intervals. *Metasternum* distinctly punctate; anteriorly with short rugae radiating from a deep depression on each side behind middle coxa. Abdomen with middle of first sternite sparsely and a little more finely punctate than metasternal disk, more or less longitudinally rugose. Four apical sternites sparsely, finely punctate. Legs with all tibiae moderately strongly arcuate.

♀. Externally similar to ♂ but with tibiae only feebly arcuate.

Distribution: Western North America, Aleutian Is.

Habits: Commonly found in stored raisins in California (Donohoe, 1939).



Figs. 24-25. (24) *Enicmus protensicollis* (Mann.); (25) *Enicmus suspectus*, Fall. (After Fall.).

***Enicmus suspectus*, Fall (fig. 25).**

Enicmus suspectus, Fall, Trans. Amer. Ent. Soc., **26**, 1899, p. 125, pl. 3, f. 17.

♂. Length, 2.0-2.25 mm. Very closely allied to *E. protensicollis*, but differing in the following particulars: (1) size distinctly smaller; (2) elytra proportionally shorter (one and three-fourths as long as broad) and less shining; and (3) each elytron with interval 3 a little convex, 5 and following intervals distinctly convex, 5 and 7 more conspicuously so, whereas in *E. protensicollis* the intervals are nearly flat or only slightly convex.

♀. Externally similar to ♂ but with tibiae only feebly instead of strongly arcuate.

Comparative notes: According to Fall (1899) this may possibly be only a geographical race of *E. protensicollis*.

Distribution: Western North America.

Habits: Commonly found in stored raisins in California (Donohoe, 1939).

[After this paper was in type, the following was found: Munro (Report on a survey of the infestation of grain by insects.—Dept. Sci. Ind. Res., 1940, London) has

recorded *Enicmus histrio*, Joy & Tomlin (Ent. Mon. Mag., **56**, 1910, p. 250) in Britain in Australian wheat imported in bulk. *E. histrio* is reddish-brown, 1.4–1.7 mm. long, and differs from the other species dealt with here in having the prosternal process elevated to form a conspicuous crest between the front coxae.

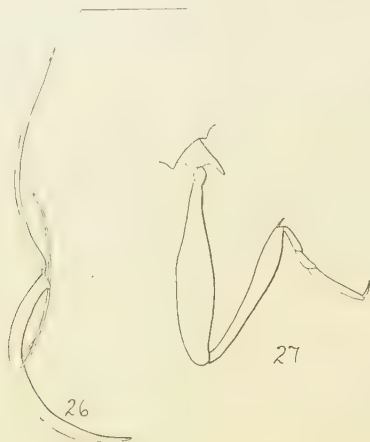
Distribution: Britain.]

Adistemia watsoni (Wollaston) (figs. 26–27).

Lathridius watsoni, Woll., Trans. Ent. Soc. Lond., **1871**, p. 253.

Cartodere bicostata, Reitt., Verh. zool.-bot. Ges. Wien, **27**, 1877, p. 183.

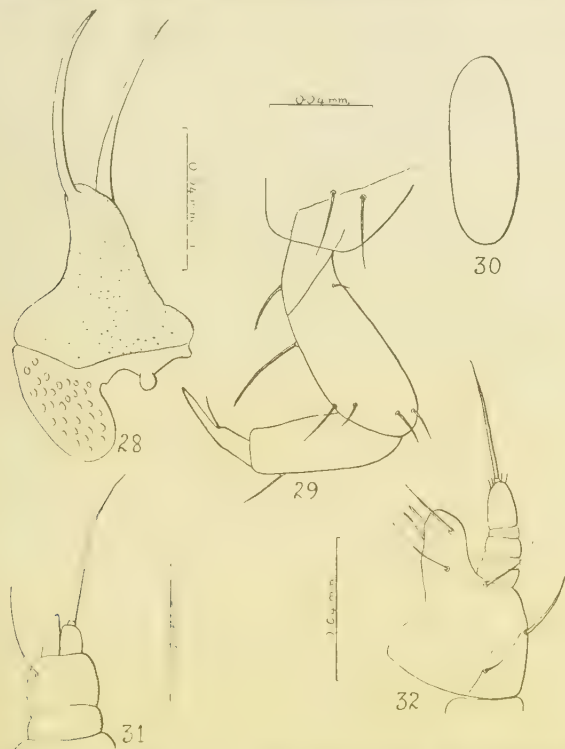
Cartodere godarti, Belon, Ann. Soc. Linn. Lyon, (n.s.) **26**, 1879, pp. 301, 302.



Figs. 26–27. *Adistemia watsoni* (Woll.) ♂: (26) right lateral view of genitalia; (27) ventral view of right hind leg.

♂. Length, 1.2–1.7 mm.; breadth, 0.35–0.54 mm. Body narrowly elongate, subparallel-sided, moderately depressed; dorsal surface rather sparsely clothed with fine, testaceous hairs which are more evident near apex of elytra, where they are often as long as eyes. Cuticle feebly shining and pale brownish-testaceous to moderately pale reddish-brown; eyes usually pale, rarely black (in nearly all other species of LATHRIDIIDAE eyes are black). Head with length greater than breadth including eyes (0.27 : 0.22 mm.); surface with deep, usually round punctures very slightly finer than facets of eyes and confluent to seldom separated by half a diameter. Eyes small (0.04 mm. broad), nearly round, moderately convex, each consisting of about six facets, and separated by more than twice their diameters from base of antennae; temples feebly converging caudally, nearly parallel, and about one and a half times as long as eyes. Antenna with club 3-segmented. Clypeus with anterior margin broadly, shallowly, arcuately emarginate and surface only finely punctate. Labrum strongly broadened and widely enclosing sides of clypeus; anterior margin very broadly and shallowly arcuately emarginate; surface with punctures only about half as coarse as those of head and distinctly sparser. Pronotum slightly longer than broad (0.26 mm. : 0.23 mm.) and base very slightly narrower than apex (0.15 mm. : 0.16 mm.). Sides rounded and moderately converging caudally; base and apex with marginal line complete and distinct, basal marginal line being distinctly broader and deeper than apical. Disk with a very long, shallow, indistinct, transverse depression occupying most of basal two-fifths; surface sculptured like head between eyes but occasionally with punctures very slightly coarser. Elytra nearly four times as long

as pronotum (1.01 : 0.26 mm.), base slightly narrower than pronotal base, and from base becoming broader caudally to broadest point which is at about middle ; apex of elytra broadly rounded, not distinctly produced. Humeri indistinct or absent. Intervals with sutural feebly elevated, particularly on apical three-fifths ; third conspicuously carinate from base to near apex ; seventh similarly carinate from basal seventh or eighth to near apex where it is joined to third ; other intervals flat. Each elytron with eight impressed, or only scarcely noticeably impressed, rows of punctures ; stria punctures on basal half of disk moderately shallow, flat-bottomed, more or less round, one-third broader to nearly twice as broad as intervals, and separated longitudinally by one-half to two-thirds a diameter. *Metasternum* without a median longitudinal line ; disk nearly flat and with round, deep punctures as coarse as facets of eyes and contiguous to separated by half a diameter. Abdomen with first sternite sculptured like metasternal disk, but with a narrow belt along caudal margin which is nearly smooth ; middle basal region more or less fused to metasternum, without a distinct dividing suture ; sternites 2 to 4 with coarse punctures distinctly sparser, particularly on sternite 4 ; sternite 5 without coarse punctures and only microscopically densely punctate. Sternites 2 to 5 each with a complete, transverse, deep, short depression along anterior margin. *Legs* with outer face of tibiae, when viewed from side, suddenly narrowed near apex ; front tarsi 2-segmented. Hind coxa (fig. 27) with a narrow spine slightly longer than an eye on mesal margin.



Figs. 28-32. *Adistemia watsoni* (Woll.). (28) ventral view of left mandible of third instar larva ; (29) anterior view of left front leg of same ; (30) egg ; (31) dorso-lateral view of right antenna of third instar larva ; (32) ventral view of left maxilla of same.

♀. Externally similar to ♂, but with front tarsi 3-segmented and hind coxae without spines.

Egg (fig. 30): Length, 0.51 mm.; breadth, 0.18 mm. Elongate oval; surface shining and not sculptured; colour whitish-opalescent.

Mature larva (figs. 28-29, 31-32): Length, 1.9 mm.; breadth, 0.29 mm. Body subcylindrical, more or less parallel-sided. Cuticle whitish with head slightly darker; setae pale testaceous. Similar in shape and general proportions to *Cartodere filum* (fig. 37), but from the latter and all other known larvae of the genus *Cartodere* it may be distinguished as follows: (1) antenna (fig. 31) with second segment slightly broader than long instead of about twice as long as broad; and (2) mandible without trace of an apically toothed, sclerotized structure on inner apex of membranous apical half (fig. 28). The second instar larva is unknown. The first instar may be distinguished from the third by its much smaller size and relatively longer setae.

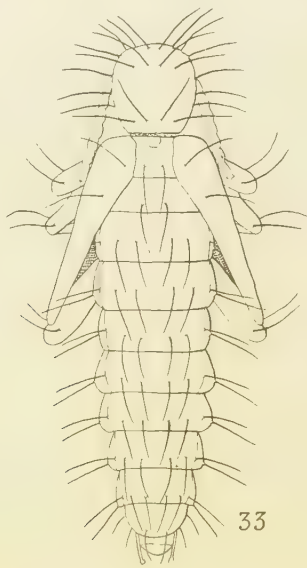


Fig. 33. Pupa of *Adistemia watsoni* (Woll.).

♂. *Pupa* (fig. 33): Length, 1.31 mm.; breadth (across third abdominal segment including elytra), 0.54 mm. Cuticle white; setae long, slender, often feebly curved, and testaceous. Head concealed from above by pronotum or only with vertex visible. Surface with seven setae on each side as follows: one slightly below anterior mesal margin of eye; one near middle more or less opposite base of antenna; one near caudal mesal margin of eye; one behind the latter and slightly nearer middle; and three forming a longitudinal row on top of front near median line, the most anterior seta of this row being more or less opposite caudal margin of eye. Antennae extend caudally and slightly outwards to caudal margin of front femora. Dorsal surface with shape and setae as shown in fig. 33. Elytra extend outwards and more or less horizontally to a point opposite caudal margin of first abdominal sternite; on about third interval with a seta near base and one near basal third. Wings absent. Abdomen with two apical segments always clothed with cuticle of third instar larva; ninth tergite without setae. *Metasternum* with middle caudal part of disk fused to first abdominal sternite, without a suture between these two sclerites. Abdomen with a

single seta on each side near caudal margin of first sternite ; sternites 2 to 4 with two setae on each side on or near caudal margin, 5 and 6 without setae. *Legs* with two setae near each knee (fig. 33). Front legs extend to middle of metasternal disk and at apex are separated by a distance equal to tarsal length ; tarsi 2-segmented. Middle pair extend to caudal margin of hind coxae and at apex are as widely separated as front pair. Hind pair extend slightly beyond caudal margin of first abdominal sternite and at apex are separated by slightly more than tarsal length ; coxa with a stout tooth near inner apex.

♀. *Pupa* : Externally similar to ♂ but with front tarsi 3- instead of 2-segmented and without a tooth on hind coxa.

Comparative notes : From all other known pupae of the LATHRIDIIDAE this may be immediately distinguished by not having a seta on or very near each caudal angle of the pronotum.

Distribution : Europe, Madeira, Canary Is., Africa, N. and S. America.

Habits : On walls of a house in Madeira (Wollaston, 1871) ; in sack of Alaskan Lepidoptera and found over a period of years in buildings in Washington, D.C. (Schwarz, 1896) ; in dust from feed store and in drugs in Washington, D.C. (Fall, 1899) ; in houses in Mexico City (Sharp, 1902) ; in large numbers in sacks containing timothy in West Virginia (Webster, 1908) ; and in the Geological Department of the British Museum (N. H.) (Champion, 1912).

About 75 adults and a few mature larvae were collected by me (iv.1941) in the British Museum (N. H.) on plant specimens attacked by *Mucor Mucedo*, L., and '*Penicillium glaucum*'. A number of these were kept alive in bottles and petri dishes where they readily fed upon the spores and hyphae of *Mucor* and the conidia and hyphae of *Penicillium*. Large numbers of spores of a mycetozoon, *Reticularia Lycoperdon*, Bull., were introduced into three separate cultures, and in each case the adults showed a marked preference for these over those of *Mucor* and *Penicillium*.

The eggs are laid singly, and the female apparently makes no attempt to conceal them. Five eggs laid during April and May were kept at a mean temperature of $65^{\circ}\text{F.} \pm 2$, and hatched in 7, 8, 9, 10 and 14 days respectively. All the larvae obtained from my cultures died while still in their first instar. Third instar larvae which were collected with the adults also fed on *Mucor* and *Penicillium*. Five days before pupation the larvae stop crawling and by means of an anal secretion firmly fix their caudal ends to the side of the glass bottle or petri dish. The pupal period of two specimens observed was 14 and 15 days respectively. About eight days after emerging from the pupae, the adults had assumed their normal colour.

***Adistemia rileyi*, Hinton.**

Adistemia rileyi, Hinton, Bull. Ent. Res. **32**, 1941, p. 180.

This species has only recently been described and figured in the pages of this journal, and there is no need to repeat the description here.

Distribution : Peru.

Habits : In Peru on walls and floor of a room used to store Nepal barley (Hinton, 1941).

***Cartodere filum* (Aubé) (figs. 34-36).**

Latridius filum, Aubé, Ann. Soc. ent. Fr., (2) **8**, 1850, p. 334.

♂. Length, 1.2-1.6 mm. Body moderately elongate, subparallel-sided, rather depressed ; dorsal surface glabrous. Cuticle shining and moderately pale reddish-brown to rufo-testaceous ; antennae and legs usually slightly paler. Head with breadth across eyes slightly greater than length, not including neck (0.30 : 0.27 mm.)

median channel moderately deep, clearly defined, and extending from base, where it is very broad, to anterior margin where it is narrower than third antennal segment; surface on either side of median channel with round, deep punctures about two-thirds as coarse as facets of eyes and seldom separated by more than half a diameter. Eyes large (0.09 mm. broad), nearly round, strongly convex, with coarse facets, and separated by slightly more than one diameter from base of antennae; temples absent. Antenna (fig. 36) with club 2-segmented. Clypeus with anterior margin scarcely noticeably arcuate, nearly truncate; surface rather smooth and only microscopically punctate. Labrum narrower than clypeus; anterior margin broadly and feebly rounded; surface sculptured similarly to clypeus. *Pronotum* across broadest point, which is at apical sixth, broader than long (0.38 : 0.30 mm.) and base slightly narrower than apex (0.28 : 0.32 mm.). Sides, particularly anteriorly, feebly dilated and shallowly, very broadly sinuate at basal two-fifths; apex with marginal line indistinct at sides and more or less completely obliterated at middle; base truncate and marginal line deep, distinct, and complete. *Pronotum* with a deep and complete

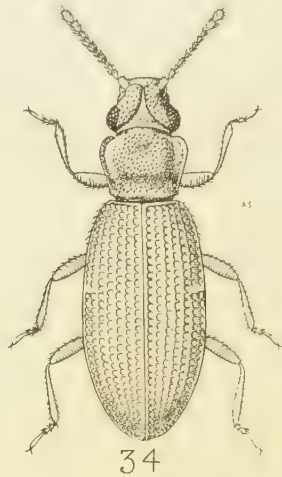


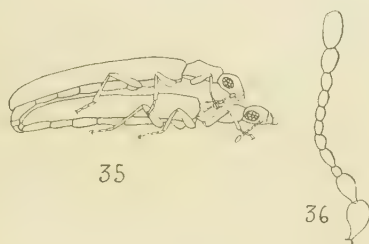
Fig. 34. *Cartodere filum* (Aubé).

transverse depression which is at middle slightly longer than apical segment of antenna; most of middle of apical half of disk occupied by a shallow to deep, oval or nearly round depression. Surface punctate like sides of head; all of extreme sides and all of basal two-fifths smooth; in some specimens bottom of basal transverse depression is densely punctate, but seldom as coarsely punctate as anterior half of disk. *Elytra* more than three times as long as pronotum (1.04 : 0.30 mm.), base only slightly broader than base of pronotum (distinctly narrower than broadest point of pronotum), and from base gradually becoming broader caudally to broadest point which is at about middle. *Humeri* indistinct. *Intervals* flat, lateral ones ever more than feebly convex; on basal two-fifths on each elytron a transverse callosity extends from lateral margin to fifth interval. Each elytron with seven moderately (near sides rather strongly) impressed striae; stria punctures on basal half of disk moderately deep, more or less round, flat-bottomed, one-third to one-half broader than intervals, and separated longitudinally by about one-half a diameter. *Mesosternum* with a deep, distinct, and complete median channel for reception of prosternal process. *Meta-sternum* without a median longitudinal line; disk feebly convex, subcordate, and

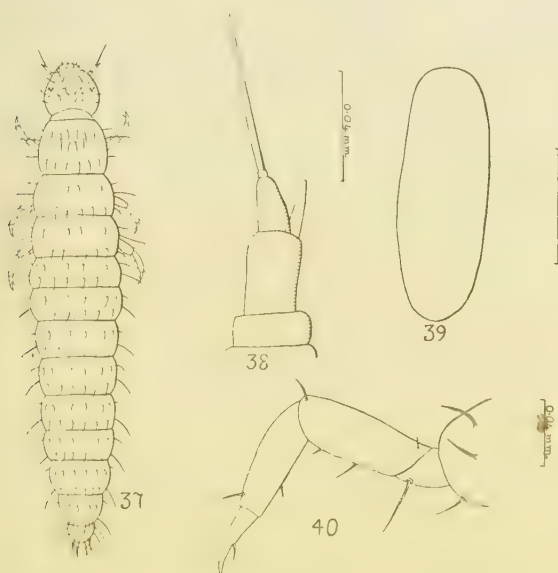
completely bounded by a deep and very broad groove ; surface of disk strongly shining, nearly impunctate ; sides with most of anterior two-thirds deeply and broadly depressed and with a large, transversely oval depression on posterior third in front of hind coxa. Abdomen with middle basal region of first sternite moderately strongly depressed near anterior margin ; sides of middle region flexed upwards so as to appear finely carinate ; from caudal end of carina on each side a deep, broad, curved depression extends nearly to caudal margin of segment. Sternites 2 to 4 with most of anterior half deeply depressed, this depressed area being much shorter at sides. Surface of sternites strongly shining and with only a few microscopic punctures.

♀. Externally similar to ♂.

Comparative notes : From all other species of *Cartodere* dealt with here it may be distinguished by its 2- instead of 3-segmented antennal club.



Figs. 35-36. *Cartodere filum* (Aubé) : (35) male and female in copula ; (36) antenna.
(After Dingler.)

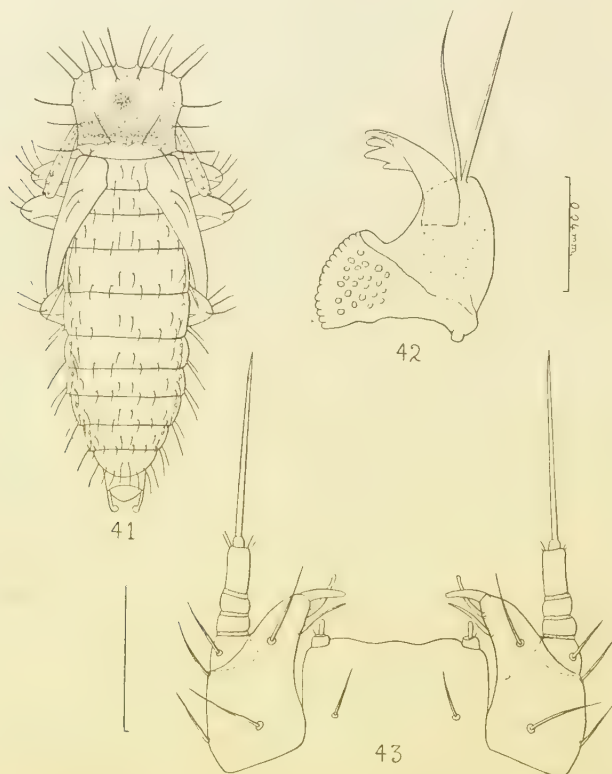


Figs. 37-40. *Cartodere filum* (Aubé) : (37) dorsal view of third instar larva ; (38) dorsal view of right antenna of same ; (39) egg ; (40) anterior view of right front leg of third instar larva.

Egg (fig. 39) : Length, 0.43–0.49 mm. ; breadth, 0.16 mm. Elongate oval, with head end slightly broader. Surface shining and not sculptured (magnification $\times 75$) ; colour whitish-opalescent.

Larva : Eichelbaum (1901), Wolff (1919), and Dingler (1928) have described the larva and pupa. The descriptions given here are based on material bred by me and now in the British Museum (N. H.).

Mature larva (figs. 37, 38, 40, 42, 43) : Length, 1.70–1.98 mm. ; breadth, 0.30–0.38 mm. Body subcylindrical, more or less parallel-sided. Cuticle white to whitish-testaceous. *Head* with setae of dorsal surface as shown in fig. 37. Each side with three pigment spots (sometimes with only two or even one) which usually disappear altogether just before pupation. Antenna (fig. 38) 3-segmented ; second segment more than twice as long as first. Mandibles (fig. 42) of both sides similar ; each with a large, feebly sclerotised apical part which has on its outer apex two very long and stout setae ; on inner apex of feebly sclerotised region is a rather heavily sclerotised structure bearing four large apical and two smaller subapical teeth ; basal sclerotised part of mandible with a grinding surface on mesal and ventral sides. Maxilla and labium with palpi and setae as shown in fig. 43. *Tergites* of thorax and abdomen with short, slender, nearly straight setae as shown in fig. 37. *Sternites* of abdomen each with a transverse row of two or three setae on each side on caudal third, the most



Figs. 41–43. *Cartodere filum* (Aubé) : (41) dorsal view of pupa ; (42) ventral view of left mandible of third instar larva ; (43) ventral view of maxilla and labium of same.

lateral of these being longer than any other seta of either ventral or dorsal surface. *Legs* all similar to front leg (fig. 40).

Second instar : Similar but slightly smaller than third, and always with at least two and generally three pigment spots.

First instar : Length, 0.5-0.7 mm. when first hatched. Differs from second and third instars by having third segment of antenna as long as instead of distinctly shorter than second, the tarsi very nearly as long (12 : 13) as tibiae instead of distinctly shorter (11 : 15), and the setae of the thorax and abdomen proportionally longer.

♂. *Pupa* (fig. 41) : Length, 1.01 mm. ; breadth (across second abdominal segment including elytra), 0.35 mm. Cuticle white ; setae moderately long, slender, more or less straight, moderately broadened at apex, and pale testaceous. *Head* completely concealed from above by pronotum or only with vertex visible ; with a deep, median longitudinal depression between eyes. Surface with six setae on each side as follows : one slightly nearer middle than anterior mesal margin of eye ; one near caudal mesal margin of eye ; one slightly behind and nearer middle than the latter ; and three forming a longitudinal row near middle, the most anterior of these being near fronto-clypeal suture and most caudal one being on vertex. Clypeus and labrum each with two much finer and shorter setae near middle. Antennae extending caudally and outwards to anterior margin of middle femora. *Dorsal surface* with shape and setae as shown in fig. 41. Elytra extend posteriorly, outwards, and slightly downwards to a point opposite anterior third of second abdominal sternite ; each elytron with two setae on about basal third of third interval. Wings absent. Abdomen up to caudal margin of second sternite and apical two tergites always clothed with skin of third instar larva ; first five sternites each with two lateral setae near caudal margin ; sternites 2 to 4 each with an additional caudal seta which is much nearer middle, 6 and 7 without setae. *Legs* with three setae on or near each knee (fig. 41). Front legs extend slightly beyond middle of metasternal disk and at apex are separated by a distance nearly equal to tarsal length. Middle legs extend to hind coxae and at apex are slightly more widely separated than front pair. Hind legs extend to middle of second abdominal sternite and at apex are separated by about three-fifths of tarsal length.

♀. *Pupa* : Externally similar to ♂, but with a small palp on either side of middle beyond caudal margin of sixth sternite.

Comparative notes : Of the known pupae of the family, this is closely related only to that of *C. filiformis*. The differences between the two species are listed under the heading of the latter.

Distribution : Europe, N. Africa, N. and S. America.

Habits : In a fungus in Algeria (Aubé, 1850) ; in herbaria in England and Scotland (Fowler, 1889) ; feeding on spores of *Polysaccum* and *Ustilago* (Belon, 1897) ; in herbaria on mouldy plants in Germany (Ganglbauer, 1899) ; on dried burdock (*Arctium*) in a herbarium in England (Thornley, 1901) ; on mouldy fungi in a herbarium in Germany (Eichelbaum, 1901) ; in a herbarium in Dublin (Johnson & Halbert, 1902) ; on dried burdock in a herbarium in England (Carr, 1916) ; in Germany in damp houses, on damp walls near water-taps and badly closing windows, on mouldy wall-paper, and in large numbers in a laboratory on mouldy papiermaché dishes (Wolff, 1919) ; in a school herbarium in Oxford (Walker, 1920) ; in Germany in stored wheat, maize and rye (Zacher, 1927) ; in Germany in boxes containing dried beer yeast and also eating mouldy bread (Dingler, 1928) ; larvae and adults on ergot of rye infected by *Trichothecium roseum* in Germany (Koltermann, 1930) ; and in herbaria in Sweden feeding on spores and hyphae of fungi where they were beneficial in small numbers but caused serious damage when present in large numbers (Kemner, 1933). In the laboratory of the Royal Botanic Gardens, Edinburgh, larvae and adults fed over a period of years on *Lycoperdon pyriforme*, *Ustilago Avenae*, and *Tilletia Tritici*. Larvae and adults were also found to feed on *Ustilago Hordei*. After

passing through the alimentary canal of the adults, a few spores of *Ustilago* survive and germinate (Gordon, 1938).

Notes on the life-history and habits of this species are given by Wolff (1919) and Dingler (1928). It has been bred by me on cultures of *Mucor Mucedo*, L., and '*Penicillium glaucum*' growing in petri dishes. Both larvae and adults also fed readily on spores of *Reticularia Lycoperdon*, Bull. According to Wolff copulation never seems to take less than two hours. The eggs are laid singly on the surface of the fungi, and the female makes no attempt to conceal them. Wolff believes that the female lays only one egg, and if this were true the populations of the beetle would be halved in the first generation. Two females kept by me which emerged on 8th May laid a total of 20 eggs by 15th July. In cultures kept at a mean temperature of $75^{\circ}\text{F.} \pm 2$ the eggs hatched in six or seven days, the duration of the first instar was five days, the second seven days, and the third instar 12 days. After feeding for nine days, the third instar larva stops feeding and by means of an anal secretion fixes itself to the sides or bottom of the glass dish. After remaining more or less motionless for three days it pupates. The duration of the pupal period varied from seven to eight days. Four pupae kept at $65^{\circ}\text{F.} \pm 2$ did not pupate until the 14th and 15th days. According to Dingler the duration of the pupal period is about two months. The shortest complete life-cycle—from time egg was laid to time adult emerged—obtained by me was 36 days ($75^{\circ}\text{F.} \pm 2$). At a temperature of $65^{\circ}\text{F.} \pm 2$ a complete life-cycle requires about 54 days and at lower temperatures may take as long as five months. When the adults first emerge from the pupa the elytra are white and the remainder of the body is pale brownish-testaceous, but the eyes are black. About two weeks after emerging the adults assume their normal colour.

***Cartodere argus*, Reitter (fig. 44).**

Cartodere argus, Reitt., Deut. Ent. Zeit., **26**, 1882, p. 164.

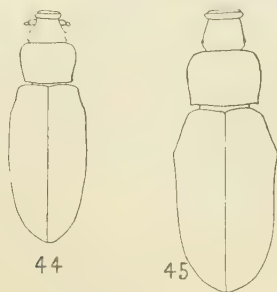
♂. Length, 1.3–1.4 mm. Body narrowly elongate, subparallel-sided, sub-depressed; dorsal surface glabrous or nearly so. Cuticle shining and reddish-brown to rufous-testaceous. Head subtriangular and broadly, feebly depressed between eyes; surface densely punctate. Eyes large, nearly round, strongly convex, and separated by more than their diameters from base of antennae; temples absent as eyes occupy hind angles of head. Clypeus broader than labrum. Labrum not enclosing sides of clypeus; anterior margin broadly, feebly rounded. Antenna with club 3-segmented, segments 9 and 10 being slightly transverse, 3 to 8 sub-moniliform and not very different in length. Pronotum transversely cordate, with base and apex subequal. Side margin explanate; basal transverse depression deep and marked by a deeper fovea at its middle; anterior half of disk without a depression. Elytra only slightly broader than pronotum at its broadest point; margins somewhat obtusely angulate at the humeri. Intervals narrow and flat or nearly so, but with seventh feebly convex. Each elytron with eight punctate striae. Ventral surface nearly impunctate. Metasternal disk on each side with a slightly curved, longitudinal impressed line extending from inner margin of hind coxa to anterior third of metasternum. Abdomen with first sternite bifoveate between coxae and with a transverse impressed line near middle of its length which extends on each side from lateral margin nearly to median line.

♀. Externally similar to ♂.

Comparative notes: From all other species of *Cartodere* with a 3-segmented antennal club this may be distinguished by the large eyes which occupy the hind angles of the head and the absence of temples.

Distribution: Europe, N. Africa, N. America.

Habits : In ground cereals in Oregon (Fall, 1899) ; in a wholesale druggist's in London (Newbery, 1907) ; and in Ohio on walls of a bathtub of a house and also in a drug store in a package of Solomon's Seal (*Polygonatum biflorum*, Ell.) (Dury, 1910).



Figs. 44-45. (44) *Cartodere argus*, Reitt. ; (45) *C. costulata*, Reitt. (After Fall.)

***Cartodere costulata*, Reitter (fig. 45).**

Cartodere costulata, Reitt., Deut. Ent. Zeit., **21**, 1877, p. 114.

♂. Length, 1.0-1.5 mm. Body elongate, subparallel, moderately convex ; dorsal surface nearly glabrous, with only sparse microscopic hairs. Cuticle moderately strongly shining and moderately dark reddish-brown to rufo-testaceous ; antennae and legs usually slightly paler. *Head* with breadth across eyes slightly greater than length not including neck (0.27 mm. : 0.24 mm.) ; median channel indistinct, broad, shallow, narrowed anteriorly, and not quite attaining anterior margin ; surface confluent and rugosely punctate with punctures one-half to nearly two-thirds as coarse as facets of eyes. Eyes very small (0.03 mm. broad), nearly round, moderately convex, each consisting of about four facets, and separated by slightly more than their diameters from base of antennae ; temples subparallel and about as long as or slightly longer than eyes. Antenna with club 3-segmented and first two segments of club more or less transverse, though segment 10 is more transverse than 9 ; segments 3 to 8 longer than broad. Clypeus distinctly broader than labrum and with anterior margin truncate ; surface not at all rugulose and only very finely punctate. Labrum with anterior margin feebly, broadly rounded and surface sculptured like clypeus. *Pronotum* across broadest point, which is at apical third, broader than long (0.39 : 0.30 mm.) and base, not including part caudal to basal marginal line, slightly broader than apex (0.32 : 0.27 mm.) Sides broadly explanate, rounded, and broadly, very shallowly sinuate opposite basal third ; apex with marginal line very shallow but distinct ; base with marginal line deep and very distinct. Pronotum with a very deep, about as long as apical segment of antennal club, nearly complete, transverse depression on basal third, this depression ending on either side before explanate area in a very deep, round pit ; anterior half of disk without a distinct depression. Surface sculptured like head but with punctures two-thirds as coarse to very nearly as coarse as facets of eyes ; surface of explanate sides and bottom of basal transverse depression frequently smooth. *Elytra* nearly three times as long as pronotum (0.84 : 0.30 mm.), base distinctly narrower than broadest point of pronotum, and from base gradually becoming broader caudally to broadest point, which is at basal third and is more strongly rounded (nearly subangulate) than any other part of margin. Humeri indistinct. Middle of sides with a broad, shallow, transverse impression. Intervals 3, 5 and 7 noticeably convex, 3 being more convex on basal third than elsewhere ; sutural interval feebly raised ; even intervals flat. Each elytron with eight feebly to moderately strongly impressed rows of punctures : stria punctures on

basal half of disk round to subquadrate, moderately deep, two to three times as broad as intervals, and separated longitudinally by two or slightly more than two diameters. *Ventral surface* of most of thorax and abdomen strongly shining and smooth or at most with only microscopic punctures. Metasternum without a median longitudinal line; disk feebly convex; on each side in front of hind coxa with a deep and broad, oval depression. Abdomen with a complete transverse depression at anterior two-fifths of first sternite, this depression being rather shallow or even absent near median line. Sternites 2 to 4 with anterior third or two-fifths very deeply depressed, 5 less strongly depressed anteriorly.

♂. Externally similar to ♀. According to Fall (1899) the ♂ bears a number of long, curved, suberect, pale yellowish hairs along the median line of the metasternum and abdomen. I have been unable to detect this secondary sexual character in the few specimens before me.

Comparative notes: The feeble median depression on the head and the costate elytra will readily distinguish it from its nearest relative, *C. filiformis*, Gyll.

Larva: The larva has been figured by Böving and Craighead (1931). It appears from their figures to be very closely related to *C. filiformis*.

Distribution: Europe, Japan, N. America.

Habits: In N. America in a cellar, in powdered lobelia root, and with *Sitodrepa* in dandelion root (Fall, 1899); and also in N. America in apartment houses, cellars of houses, drug stores, etc., and infesting foodstuffs, flour, macaroni, drugs, herbarium material, etc. (Cotton & Good, 1937).

***Cartodere filiformis* (Gyllenhal) (fig. 46).**

Latridius filiformis, Gyll., Ins. Suecica, **1** (4), 1827, p. 143.

Latridius parallela, Mann., in Germar, Zeit. Ent., **5**, 1844, p. 106.

Latridius tantilla, Mann., *l. c.*



Fig. 46. *Cartodere filiformis* (Gyll.).

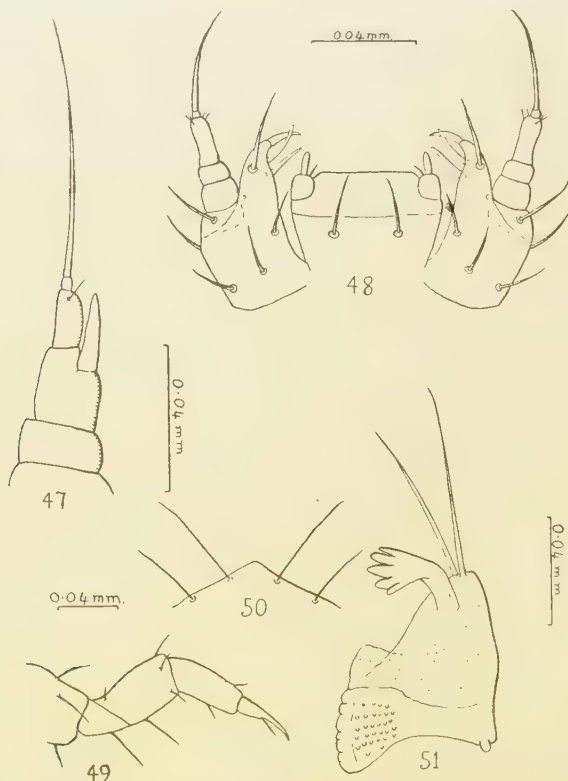
3. Length, 1.2-1.4 mm. Body elongate, subparallel-sided, moderately convex; dorsal surface smooth, glabrous, with some sparse setae on the flanks. Antennae shining and reddish-brown to rufo-testaceous; antennae and legs usually distinctly jointed. Head with broad shallow transverse depression that has a median longitudinal pit, 0.22 mm.; front without a median longitudinal impression, though with basal region of front shallowly depressed; eye with a narrow transverse median and transverse submedian sulcus with punctures about two-thirds as coarse as facets of eyes. Eyes small 0.05 mm. broad, longer than broad, barely convex, with a spacing at least two to six times, and separated by slightly more than their lengths from base of antennae; temples slightly shorter than eyes and nearly parallel. Antennae with club abruptly 3-segmented; segments 4 and 5 about as long as broad, 4 distinctly longer than broad; segments 5 to 8 equal in width, 8 somewhat longer. Clypeus with a shallow transverse sulcus; surface only microscopically punctate, not rugulose. Labrum with anterior margin broadly, shallowly punctate, the punctures being deeper in the middle; surface brownish, with a shallow transverse sulcus, broader than long, 0.25 mm. long and broad, not reaching part beyond to reach the apex of the clypeus, 0.28 : 0.25 mm. Sides broadly explanate, arcuate, and broadly, shallowly sinuate at basal third; apex with marginal line scarcely noticeable on middle but slightly more distinct at sides; base from the anterior margin to the posterior pronotum with a very deep, as long as apical two segments of antennal club, nearly complete, transverse depression occupying the area between basal third and middle; this depression ending on upper side in a shallow transverse sulcus very deep, broad part anterior half of disk not depressed. Surface sculptured but head and sides are more sculptured. Anterior coxae sinuate with transverse sulcus and a shallow transverse basal third with transverse depression; transverse sulcus about as apical two segments times as long as pronotum 0.82 : 0.27 mm., base slightly narrower than broadest part of pronotum; hind tibiae with a shallow transverse depression; hind tibiae with a shallow transverse depression about basal third or sometimes middle. Humeri not prominent. Intervals flat. Each interval with eight rows of punctures, the first row of punctures being the fifth and sixth rows joined together just before middle; serial punctures on basal half of disc round or subangular, two to three times as small as intervals and separated longitudinally by one-third to one-half a diameter. *Metasternum* with caudal part very deeply depressed between coxae. *Metasternum* without a median longitudinal line. Disk moderately convex but on posterior third with a deep very deep transverse depression about basal third and a deep pit at front of each coxa; surface strongly shining and with only a few microscopic punctures. Abdomen with a longitudinal transverse depression on first segment, this depression being the broadest middle of length, on basal third not deeper and not so deep at length of sides. Segments 2 to 5 each with a deep anterior transverse depression occupying the third to one-half of segment on middle, and about middle of segment on sides. Surface of sternites with only a few microscopic punctures and strongly shining, but the lateral disk.

2. Externally similar to 3.

Comparative notes: This species is closely related to *C. cosularis*, Reitt., but may be distinguished as follows: (1) head without a median depression on anterior part of front; (2) the basal transverse depression on the pronotum is about as long as the transverse sulcus of the antennal club, whereas in *C. cosularis* it is somewhat shorter, as long as apical segment of antennal club; (3) the elytral intervals are flat; (4) the fifth and sixth rows of punctures on each elytron are not joined before middle of basal third apex; and (5) the depression in front of basal third is not joined together by a deep transverse depression whereas in *C. cosularis* there is the transverse depression joining the lateral pits.

Length 1.4 mm. Head 0.44 mm. Flagellum with basal third slightly broader. Surface not sculptured and shining; colour whitish-opalescent.

Mature larva (figs. 47-51): Length, 1.71 mm.; breadth, 0.32 mm. Body sub-cylindrical, more or less parallel-sided. Cuticle white to whitish-testaceous. General appearance and chaetotaxy of both dorsal and ventral surface identical or nearly so to *C. filum*, from which it may be distinguished as follows: (1) antenna with accessory spine arising well before instead of at apex of second segment (*cf.* figs. 47, 38); (2) anterior margin of head (clypeus?) triangularly pointed instead of broadly rounded nearly truncate (fig. 50); mandible (fig. 51) with apical sclerotised structure bearing five large instead of four large and two small apical teeth (*cf.* figs. 51, 42); and (4) all, or nearly all, setae of dorsal surface distinctly longer than their respective segments, whereas in *C. filum* only the postero-lateral setae and all setae of ninth tergite are as long as their respective segments, the other setae being distinctly shorter than their respective segments.



Figs. 47-51. Third instar larva of *Caridodere filiformis* (Gyll.): (47) dorso-lateral view of right antenna; (48) ventral view of maxilla and labium; (49) anterior view of left front leg; (50) outline of front margin of head or clypeus (?); (51) ventral view of left mandible.

Second instar: Slightly smaller but otherwise similar to third.

First instar: 0.65 mm. long and 0.14 mm. broad when first hatched. Differs from third (mature larva) in the same particulars as that of *C. filum*.

Pupa: Length, 0.98 mm.; breadth (across second abdominal segment including clytra), 0.35 mm. Similar to *C. filum*, but differs in the following particulars: (1) head

without a deep longitudinal depression on middle of front ; (2) eyes much smaller ; (3) antenna with club 3- instead of 2-segmented ; and (4) pronotum with middle of apical half of disk flat or at most feebly concave and never with a deep depression.

Distribution : Europe, U.S.S.R., Japan, N. America.

Habits : In old flour barrels in U.S.A. (Schwarz, 1876) ; in fungus in Britain (Fowler, 1889) ; on mould on a wall and on roots of soapwort (Belon, 1897) ; in a house in Britain (Fowler & Donisthorpe, 1913) ; in a mouldy bread-roll in England (Keys, 1920) ; in drugs in Germany (Zacher, 1927) ; in a wine cellar in England (Stott, 1928) ; and in samples of dried beer yeast in Germany (Dingler, 1928). I have taken it (iv-vi.1941) in numbers in mouldy bread and on mouldy roofs and walls in two London houses.

Several cultures of this species were successfully kept in the laboratory. They were fed on *Mucor Mucedo*, L., '*Penicillium glaucum*', and *Reticularia Lycoperdon*, Bull. The eggs are laid singly on the surface of the fungi, and in one or two days are usually completely concealed by fungous growth. The egg takes 11-12 days ($63^{\circ}\text{F.} \pm 1$) to hatch. The first instar lasts 5 days (larvae and pupae were kept at an average temperature of $67^{\circ}\text{F.} \pm 1$), the second 10 days and the third 9 days. The third instar larva feeds for 5 days, and after this fixes its caudal end firmly to the sides of the petri dish or to a piece of bread by means of an anal secretion. It pupates 4 days after it has stopped feeding, and the pupal period lasts 16 days. The total time taken from egg to adult is thus 51-52 days. The adult assumes its normal colour about a week after it emerges from the pupa.

Cartodere ruficollis (Marshall) (fig. 52).

Corticaria ruficollis, Marsh., Ent. Brit., **1**, 1802, p. 111.

Latridius liliputana, Villa, Col. Eur., 1833, p. 36.

Corticaria pulicarius, Melsh., Proc. Acad. Nat. Sci. Philad., **2**, 1844, p. 115.



Fig. 52. *Cartodere ruficollis* (Marsh.). (After Fall.)

♂. Length, 1.0-1.2 mm. Body moderately elongate and moderately strongly convex ; dorsal surface glabrous. Cuticle shining and reddish-brown ; elytra usually distinctly darker reddish-brown than pronotum ; antennae, legs, and ventral surface brownish-testaceous. Head with breadth across eyes slightly greater than length (0.22 mm. : 0.19 mm.) ; front without trace of median longitudinal depression ; surface rugosely and frequently confluent punctate with punctures which are as coarse as or nearly as coarse as facets of eyes. Eyes small (0.03 mm. broad), nearly round, moderately strongly convex, each consisting of about 20 facets, and separated by one and a half diameters from base of antennae ; temples converging caudally and distinctly shorter than eyes. Antenna with club abruptly 3-segmented, segment 9 slightly longer than broad, 10 subquadrate, and 11 distinctly longer than broad ;

segment 4 nearly twice as long as 3; 5 to 8 gradually becoming shorter but all longer than broad. (Clypeus broader than labrum and anterior margin shallowly, arcuately emarginate for its entire breadth; surface not rugulose and only microscopically punctate. Labrum with anterior margin broadly, feebly rounded and surface punctate like clypeus. *Pronotum* across broadest point, which is at apical fifth, broader than long (0.26 : 0.22 mm.) and base about as broad as apex (0.19 mm.). Sides nowhere explanate, arcuate, and very deeply and rather narrowly emarginate near basal fourth; apex without a distinct marginal line; base truncate and marginal line shallow and rather indistinct. *Pronotum* with a deep, short (not as long as apical segment of antenna), complete, transverse depression; surface slightly more coarsely punctate and rugulose than head. *Elytra* more than three times as long as *pronotum* (0.76 : 0.22 mm.), base about as broad as broadest point of *pronotum*, though broadest point of *elytra* is much broader than broadest point of *pronotum* (0.43 : 0.26 mm.), and from base rounded caudally to broadest point of *elytra* which is about middle. Intervals flat except for 5 and 6 which are moderately convex. Each *elytron* with seven very feebly to moderately impressed rows of punctures; striae punctures on basal half of disk deep, round to subquadrate, two to three times as broad as intervals, and separated longitudinally by two or slightly more than two diameters. *Metasternum* with caudal half of disk strongly, transversely depressed, this depression being deeper at sides; surface strongly shining and nearly impunctate. Abdomen with a complete, transverse depression on middle of first sternite; four apical sternites with anterior third to two-fifths strongly depressed. Surface of all sternites strongly shining and nearly impunctate.

♀. Externally similar to ♂.

Comparative notes: From all other species of *Cartodere* dealt with here it may be distinguished by having seven rows of punctures on each *elytron*.

Distribution: Europe, N. Africa, Madeira, Canary Is., N. and Central America.

Habits: In Britain in haystack and other refuse, in fungi, etc. (Fowler, 1889); in a London granary (Donisthorpe, 1897); in dry dung and in storks' nests in Germany (Reitter, 1911); common in haystack refuse in Britain (Fowler & Donisthorpe, 1913); in a sample of wheat in Montana (Cooley, 1914); common at bottom of haystacks in Britain (Benett, 1915); in Germany in damp houses on mouldy wall-paper particularly near water-taps and badly closing windows, in large numbers in chemist shop, and in fair numbers in laboratory on mouldy paper (Wolff, 1919); in granaries in the Scilly Islands (Blair, 1931); and in flour mills, houses, museums, and barns and in flour, grain, etc. (Cotton & Good, 1937).

***Migneauxia orientalis*, Reitter.**

Migneauxia orientalis, Reitt., Mitt. Münch. Ent. Ver., **1**, 1877, p. 139.

Length, 1.2–1.5 mm. Body broadly obovate; dorsal surface moderately densely pubescent with short hairs. Cuticle shining and brownish-testaceous; antennae and legs paler and more nearly testaceous. *Head* with antennae 10-segmented; club abruptly 3-segmented. *Pronotum* transverse; sides strongly and rather evenly rounded and behind middle conspicuously toothed; on each side in front of base with a broad, shallow, longitudinal impression; disk finely and sparsely punctate, the punctures being somewhat denser towards sides; surface between punctures densely, microscopically alutaceous. *Elytra* with intervals flat and feebly rugose. Strial punctures moderately fine and moderately sparse. Pubescence arranged in longitudinal rows in striae and on intervals, the pubescence of striae and intervals being more or less equal in length. *Legs* with second tarsal segment only slightly shorter than first; third segment as long as combined length of first two.

Distribution: Europe, India, China, Japan, S. America.

Habits : Imported in rice into Denmark (Reitter, 1891 ; Belon, 1897 ; Ganglbauer, 1899 ; Belon, 1902).

Melanophthalma picta (Leconte).

Corticaria picta, Lec., Proc. Acad. Nat. Sci. Philad., **7**, 1855, p. 303.

♂. Length, 1.25 mm. Body ovate, moderately convex ; dorsal surface with pubescence short, very fine, and pale testaceous. Cuticle shining and colour brownish to reddish-testaceous ; elytra with a transverse median darker patch and usually also with a basal and an apical darker brown patch ; elytra sometimes entirely dark brown except from extreme base ; elytra very rarely without dark markings. *Head* sparsely and very finely punctate. Temples distinct and parallel. Antenna with club 2-segmented. *Pronotum* subquadrate, a little broader than head. Sides feebly angulate when viewed from above, straight and feebly converging in front of angulation, and broadly and feebly sinuate behind angulation ; disk without a basal, median depression but with sides shallowly and transversely depressed posteriorly. Surface sparsely, finely, distinctly punctate ; surface between punctures reticulately alutaceous. *Elytra* one-half broader than pronotum, rather short, ovate, and with sides arcuate. Intervals flat and with very fine punctures. Striae not impressed ; strial punctures fine (slightly coarser than those of intervals), distinct, and rather widely separated. *Prosternum* in front and metasternum at sides sparsely punctate. Abdomen with two caudally diverging striae on first sternite ; with five visible sternites. *Legs* with front coxae distinctly but narrowly separated and middle coxae separated by two-thirds of coxal breadth. Front tibiae with a moderately long and dense fringe of hairs.

♀. Externally similar to ♂ but abdomen usually with part of sixth sternite externally visible and apical fringe of hairs on front tibiae shorter.

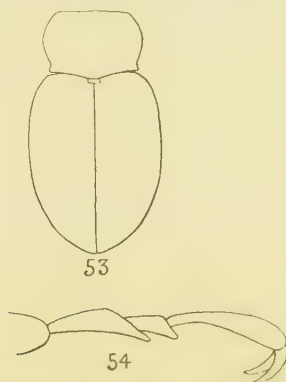
Comparative notes : This species may be readily distinguished from *M. americana* by the 2- instead of 3-segmented antennal club.

Distribution : N. America.

Habits : On fresh apples imported into Germany from N. America (Kraepelin, 1900) ; and among damp leaves in Indiana (Blatchley, 1910).

Melanophthalma americana (Mannerheim) (figs. 53-54).

Corticaria americana, Mann., in Germar, Zeit. Ent., **5**, 1844, p. 50.



Figs. 53-54. *Melanophthalma americana* (Mann.) : (53) outline of adult ; (54) hind tarsus. (After Fall.)

♂. Length, 1.3–1.8 mm. Body obovate, convex; dorsal surface with pubescence moderately dense, rather short, and recumbent. Cuticle shining and yellowish to reddish-testaceous. *Head* sparsely, finely punctate. Eyes rather small, prominent, and separated on front by more than twice their longest diameter; temples very short but discernible. Antenna with club 3-segmented; outer segments of antennal funicle longer than broad, the sixth and seventh particularly so; segment 8 sub-globular. *Pronotum* transverse, subcordate, strongly rounded in front, and straight posteriorly; lateral margins usually finely crenulate posteriorly, the hind angles being marked by a prominent tooth; disk with basal depression moderately shallow and somewhat transverse; surface with fine punctures which are separated by one to two diameters. *Elytra* about three times as long as pronotum, broadly obovate, broadest point at middle, and sides regularly rounded. Intervals flat and with punctures finer than those of striae. Striae very feebly impressed and stria punctures moderately fine. *Prosternum* with a few indistinct punctures in front of coxae, along anterior margin, and others, which are more distinctly impressed, in transverse depression along side posterior margin. *Metasternum* distinctly longer than first abdominal sternite behind coxae; disk finely, sparsely punctate; metasternal episterna impunctate or nearly so. Abdomen without striae on first sternite; sternite 6 distinct and nearly as long as 5, surface of sternites finely and sparsely punctate. *Legs* with middle coxae separated by about breadth of coxa. Front tibia with a small tooth on inner side of apical half. Tarsi (fig. 54) with second segment distinctly shorter than first.

♀. Externally similar to ♂ but without a tooth on inner side of front tibia.

Comparative notes: This species may be distinguished from *M. picta* as follows: (1) antennal club 3- instead of 2-segmented; (2) abdomen with six visible sternites in both sexes instead of with six only in female; (3) first abdominal sternite without striae; and (4) male with a tooth on inner side of front tibia.

Distribution: N. America, Taiwan.

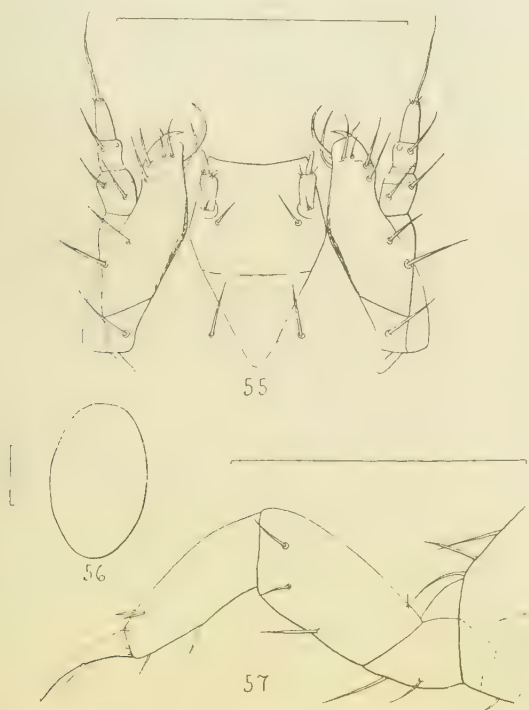
Habits: In flour mills in Virginia (Cotton & Good, 1937).

Corticaria fulva (Comolli).

Latridius fulvus, Comolli, De Col. Novocomi, 1837, p. 39.

♂ Length, 1.6–2.0 mm. Body elongate, rather narrow, and moderately convex. Cuticle shining and yellowish-brown. *Head* with punctures about two-thirds as coarse as facets of eyes, shallow, indistinct, and separated by one to two diameters; surface between punctures densely, microscopically alutaceous. Eyes moderately feebly convex and vertical diameter noticeably greater than horizontal (0.137: 0.082 mm.); temples behind dorsal part of eyes about as long as eighth antennal segment. Antenna with segments 8, 9 and 10 about as broad as long, 10 being slightly transverse; all other segments longer than broad. *Pronotum* with broadest point, which is before middle, broader than long (0.54: 0.46 mm.). Sides everywhere coarsely and distinctly serrate, but slightly more coarsely so near base. Base in front of scutellum with depression large, nearly round, and moderately deep. Surface with punctures round to oval, as coarse as or slightly coarser than facets of eyes, moderately deep, and contiguous to separated by nearly one diameter; surface between punctures densely, evenly, microscopically alutaceous. *Elytra* nearly three times as long as pronotum (1.34: 0.46 mm.); base slightly narrower than broadest point of pronotum. Strial punctures on basal half of disk distinctly coarser than punctures of pronotum, round to subquadrate, half as broad to as broad as intervals, and separated longitudinally by one to two diameters, though at base they are often denser; intervals with punctures slightly but distinctly finer than stria punctures and separated longitudinally usually by two to four diameters. Pubescence consisting of alternate rows of short, more or less decumbent hairs and suberect to erect,

longer hairs which are as long as apical segment of antennal club; long hairs arise from punctures of intervals and short hairs from strial punctures. *Metasternum* with discal punctures distinctly finer than facets of eyes, shallow, and usually separated by two to three diameters, seldom by one. Abdomen with surface of sternite 5 not distinctly depressed; apical margin feebly reflexed at middle. *Legs* with basal segment of front tarsi feebly dilated. Front and middle tibiae with a fine, short tooth on inner side near apex.



Figs. 55-57. *Corticaria fulva* (Comolli): (55) ventral view of maxilla and labium of third instar larva; (56) egg; (57) front leg of third instar larva.

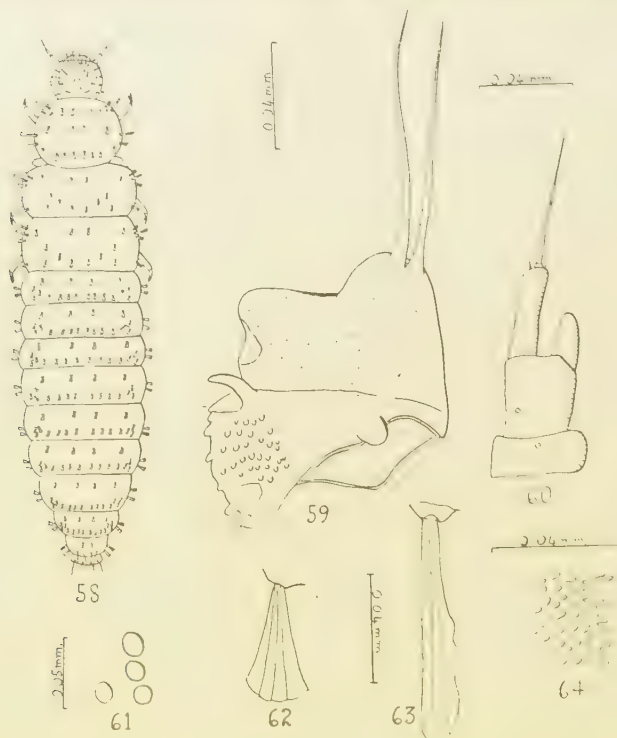
♀. Externally similar to ♂ but with basal segment of front tarsi not dilated and without a tooth on inner apex of front and middle tibiae.

Immature stages: Thevenet (1874) has described and figured the larva and pupa. The descriptions of the immature stages given here are based on material reared in the laboratory by me.

Egg (fig. 56): Length, 0.52 mm.; breadth, 0.24 mm. Broadly oval. Surface shining, not sculptured; colour whitish-opalescent.

Mature larva (figs. 55, 57-64): Length, 2.65 mm.; breadth, 0.68 mm. Body sub-cylindrical and more or less parallel-sided. Cuticle white, not shining, and dorsal and ventral surface very finely and more or less densely tuberculate (fig. 64). *Head* with setae of dorsal surface as shown in fig. 58; anterior and median areas with pointed setae; sides with fan-shaped setae. Each side with four ocelli (fig. 61), three

in an obliquely transverse row and one slightly caudal to most mesal of row. Antenna (fig. 60) 3-segmented; segment 2 more than twice as long as 1 and segment 3 only slightly longer than 2; accessory spine of segment 2 not visible from above. Mandibles (fig. 59) of both sides similar; each with a large, feebly sclerotised part which has on its outer apex two very long and stout setae; basal sclerotised part with numerous unequal teeth on inner side and a large ventral grinding surface. Maxilla and labium with palpi and setae as shown in fig. 55. *Tergites* of thorax and abdomen with short, flattened, fan-shaped setae arranged as shown in fig. 58; ninth and tenth (?) tergites with two pointed setae on each side of middle. *Sternites* of abdomen each with a fan-



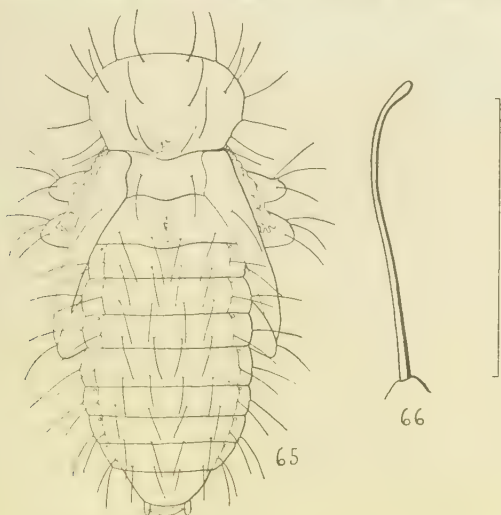
Figs. 58-64. Third instar larva of *Corticaria fulva* (Comolli): (58) dorsal view of mature larva; (59) ventral view of left mandible; (60) outer lateral view of right antenna; (61) ocelli; (62) seta from median region of pronotum; (63) seta from lateral margin of pronotum; (64) enlarged section of cuticle of pronotum showing fine tubercles.

shaped seta on middle of side, a very long (longer than segment), pointed, sublateral seta, and a much shorter, pointed seta near middle; ninth sternite with a transverse row consisting of four long, subequal, pointed setae on each side on anterior fourth. *Legs* all similar to front leg (fig. 57).

Second instar: Similar but smaller than third instar and with head nearly as broad as prothorax instead of distinctly narrower.

First instar: Similar to second and third instars but with head (at least when first hatched) distinctly broader than prothorax, third antennal segment at least one-third longer than second, and tarsus nearly as long (7:8) instead of much shorter (16:25) than tibia.

Pupa (figs. 65-66) : Length, 1.91 mm. ; breadth (across third abdominal segment including elytra), 0.95 mm. Cuticle white ; setae long, slender, straight or feebly curved, pale testaceous, and each feebly but distinctly broadened at apex. *Head* completely concealed from above by pronotum or only with vertex visible. *Surface* with nine setae on each side as follows : one near anterior third of mesal margin of eye ; two near median line opposite base of antenna ; two similar to the latter but nearer middle and opposite caudal third of eye ; one near middle caudal margin of eye ; one on same level as the latter but nearer middle ; and one on each side of and slightly caudal to the latter. Antenna extending caudally and slightly outwards to middle of middle femora. *Dorsal surface* with shape and setae as shown in fig. 65. Elytra extending caudally and ventrally to anterior third of third abdominal sternite ; each elytron with a single seta on basal fourth on third interval. Wings extending caudally and ventrally to posterior margin



Figs. 65-66. *Corticaria fulva* (Comolli) : (65) dorsal view of pupa ; (66) enlarged view of seta of pronotum.

of third abdominal sternite and more or less completely concealed by elytra. Abdomen with apical two or three segments always clothed with cuticle of third instar larva ; sternites 2 to 5 with a single sublateral seta on each side near caudal margin. *Legs* with three long setae on or near knee of first two pairs (fig. 65) ; hind knee with only a single seta. Front pair extending to caudal margin of metasternal disk and at apex separated by a distance equal to slightly less than length of tarsi. Middle pair extend to middle of first abdominal sternite and at apex are separated by a distance more or less equal to tarsal length. Hind pair extend to anterior margin of fourth abdominal sternite and are contiguous at apex.

Comparative notes : The short and stout abdominal urogomphi which are not knobbed at apex together with the peculiar arrangement of setae on the knees (3-3-1) will serve to distinguish it from all other known pupae of the LATHRIDIIDAE.

Distribution : Cosmopolitan.

Habits : On roots of *Gypsophila struthium*, L., kept in a cellar in France (Thevenet, 1874) ; in vegetable refuse in Britain (Fowler, 1889) ; in a London granary (Donisthorpe, 1897) ; common in cellars in Germany (Ganglbauer, 1899) ; in a wine cellar

in England (Joy, 1906); common in a cellar in England (Sharp, 1908); in cellars and granaries in Germany (Reitter, 1911); in a London warehouse (Newbery, 1912); in a mill in England (Walker, 1912); in a corn shop and in cellars in Britain (Fowler & Donisthorpe, 1913); in a leather factory in Cardiff (Tomlin, 1913); on dried burdock in a herbarium in Nottinghamshire (Carr, 1916); and in floor sweepings of a London cacao and spice warehouse (Richards & Herford, 1930). I have taken all stages in large numbers on mouldy bread in two London houses.

This species has been reared by me on mixed cultures of '*Penicillium glaucum*' and *Mucor Mucedo*, L., growing on beef agar in petri dishes. Both larvae and adults feed on the hyphae and conidia or spores of the fungi. They appeared to show a marked preference for those of *Penicillium*, but in one experiment were successfully reared on a pure culture of *Mucor*. As usual in the LATHRIDIIDAE, the eggs are laid singly on the surface of the hyphae. A complete life-cycle—from the time the egg was laid to the time the adult emerged from the pupa—took 40 days at a mean temperature of $65^{\circ}\text{F.} \pm 2$. This time was divided as follows: egg 8 days; first instar 7 days; second instar about 7 days; third instar 8 days, the last three of which are spent resting and not feeding; and pupa 10–11 days. When the adult first emerges from the pupa, the cuticle is pale brownish-testaceous with nearly white elytra, but after three or four days it assumes its normal colour.

Corticaria pubescens (Gyllenhal) (fig. 67).

Latridius pubescens, Gyll., Ins. Suecica, 1 (4), 1827, p. 123.



Fig. 67. *Corticaria pubescens* (Gyll.).

♂. Length, 2.3–3.0 mm. Body stout, obovate, moderately strongly convex. Cuticle shining and moderately dark brownish-red; antennae and tarsi brownish-testaceous. Head with punctures slightly finer to slightly but distinctly coarser than facets of eyes, round to oval, moderately deep, and usually separated by less than one diameter at sides to one or two diameters on middle of front; surface between punctures with a dense, reticulate, alutaceous microsculpture. Eyes strongly convex and

nearly round (vertical diameter slightly greater than horizontal, 6.5 : 5) ; temples well developed and behind dorsal part of eyes about as long as eighth antennal segment. Antenna with first two segments of club distinctly longer than broad. *Pronotum* with broadest point, which is before middle, broader than long (0.58 : 0.49 mm.). Sides irregularly dentate from base to apex ; near base with teeth distinctly coarser. In front of scutellum with a large, moderately deep, oval depression ; on each side on basal third with a very shallow, scarcely noticeable, transverse depression which extends to median basal depression. Surface with deep, round to oval punctures about as coarse as those of head and separated by one-half to one diameter ; surface between punctures alutaceous like head. *Elytra* slightly more than three times as long as pronotum (1.64 : 0.49 mm.) ; base slightly narrower than broadest point of pronotum ; middle very much broader than pronotum. Basal half of disk with punctures deep, usually subquadrate, half as broad to nearly as broad as intervals, and separated longitudinally by half to one diameter ; intervals with punctures deep, round to subquadrate, frequently as coarse as stria punctures, and arranged in irregular and indefinite rows so that they are often difficult to distinguish from true stria punctures. Pubescence consisting of rows of short more or less decumbent hairs alternating with rows of longer, suberect to erect hairs ; long hairs arise from punctures of intervals and short hairs from stria punctures. *Metasternum* with discal punctures deep, round, slightly but distinctly coarser than facets of eyes, and usually separated by one to one and a half diameters ; surface between punctures very finely, transversely alutaceous. Abdomen with middle base of fifth sternite shallowly, transversely depressed and middle apical margin with a short, rounded tooth directed vertically downwards. *Legs* with basal segment of front tarsi moderately strongly dilated. Front and middle tibiae with a fine, short tooth on inner side near apex.

♀. Externally similar to ♂, but with fourth abdominal sternite feebly depressed on middle apical two-thirds ; fifth sternite with all of middle deeply depressed ; without a tooth on apical margin of fifth sternite ; basal segment of front tarsi not dilated ; and front and middle tibiae without teeth on inner side near apex.

Comparative notes ; This is the largest and most easily recognizable species dealt with here. It is perhaps most closely related to *C. fulva* from which it may be distinguished as follows : (1) surface of head with punctures deep and distinct instead of shallow and indistinct ; (2) eyes rounder and more strongly convex ; (3) antenna with segments 8, 9 and 10 much longer than broad instead of as broad as long ; (4) basal half of elytral disk with punctures of intervals as coarse as stria punctures instead of distinctly finer ; (5) metasternal disk with punctures coarser than facets of eyes instead of distinctly finer ; and (6) middle apical margin of fifth abdominal sternite of male with a distinct tooth, whereas in *C. fulva* there is no tooth here.

Immature stages : Perris (1852) has described the larva and pupa. The larva may be distinguished from that of *C. fulva* by having some of the lateral setae of the thorax and first eight abdominal segments long, slender, and round in cross section, whereas in *C. fulva* the lateral setae are all fan-shaped and rather flat. His description and figure of the pupa is not sufficiently detailed to enable me to distinguish it from that of *C. fulva*.

Distribution : Nearly cosmopolitan.

Habits : In Britain in haystack and flood refuse, decaying sea-weed, moss, hay, straw, etc. (Fowler, 1889) ; in houses and granaries, on the bark of trees and in vegetable detritus in France and in stored tobacco in the West Indies and in Australia (Belon 1897) ; in moss in England (Morley, 1899) ; in stored tobacco (Escherich, 1914) ; in damp cellars in England (Carr, 1916) ; in cellars and granaries in Germany (Zacher, 1927) ; and in an old birds' nest in England (Donisthorpe, 1939).

Corticaria fenestralis (Linnaeus).

Dermestes fenestralis, Linn., Syst. Nat., **10**, 1758, p. 356.

Corticaria ferruginea, Marsh., Ent. Brit., **1**, 1802, p. 111.

♂. Length, 1.5–1.8 mm. Body obovate, nearly parallel-sided, and moderately strongly convex. Cuticle shining and moderately pale to dark reddish-brown; antennae and tarsi frequently brownish-testaceous. *Head* with punctures round, moderately deep, slightly but distinctly finer than facets of eyes, and usually separated by less than one to one diameter; on middle of front punctures are finer and slightly sparser and near anterior margin they are very fine; surface between punctures densely, reticulately, microscopically alutaceous. Eyes large, strongly convex, and nearly round (vertical diameter slightly greater than horizontal, 6:5); temples behind dorsal part of eyes very short and poorly developed. Antenna with segments 8, 9 and 10 about as broad as long. *Pronotum* with broadest point, which is slightly before middle, distinctly broader than long (0.52:0.41 mm.). Sides very finely and not distinctly serrate on anterior half; posterior half distinctly serrate, the teeth being moderately coarse near hind angles. Base in front of scutellum with a shallow oval depression about as long as apical segment of antenna. Surface with punctures round, moderately shallow, as coarse as facets of eyes or slightly finer, and usually separated by slightly more or slightly less than one diameter; surface between punctures reticulately alutaceous like head. *Elytra* three times as long as pronotum (1.23:0.41 mm.); base slightly but distinctly narrower than pronotum. Basal half of disk with stria punctures deep, more or less round, much coarser than those of pronotum, about half as broad as intervals, and separated longitudinally by more than one to slightly less than one diameter; each interval with two irregular rows of punctures but sometimes these punctures are so arranged that each interval appears to have only one very irregular row of punctures; punctures of intervals seldom more than half as coarse as stria punctures. Pubescence short, decumbent, rather sparse, subequal. *Metasternum* with discal punctures round, rather shallow, distinctly finer than facets of eyes, and usually separated by two to three diameters; surface between punctures densely, reticulately alutaceous. Abdomen with fifth sternite not depressed. *Legs* with basal segment of front tarsi moderately dilated. Front and middle legs with a fine, indistinct tooth on inner side near apex of each tibia.

♀. Externally similar to ♂ but with basal segment of front tarsi not dilated and without a tooth on inner side near apex of front and middle tibiae.

Distribution: Europe, Asia, N. America.

Habits: In vegetable refuse, moss, etc. in Britain (Fowler, 1889); in a hotel in France (Deville, 1908); in the University Museum, Oxford (Walker, 1920); in flour in house in Missouri (Cotton & Good, 1937); and in England in cut grass, hay refuse, in dead jackdaw, under pine bark, and abundant in manure-heaps (Donisthorpe, 1939).

Corticaria subtilissima, Reitter.

Corticaria subtilissima, Reitt., Mitt. Münch. Ent. Ver., **1**, 1877, p. 139.

Length, 0.9–1.0 mm. Body subparallel-sided and moderately feebly convex. Cuticle shining and blackish-brown; antennae and legs reddish-brown or brown. *Head* with surface sparsely and finely punctate; surface between punctures microscopically alutaceous. Temples short but distinct. *Pronotum* scarcely broader than long; base in front of scutellum with a very large and deep depression; surface sparsely punctate and with an alutaceous microsculpture between punctures. *Elytra* three times as long as pronotum and only slightly broader than pronotum; apex of elytra not completely covering caudal part of last abdominal tergite. Strial punctures very fine. Pubescence short, very sparse, and consisting of more or less equal hairs.

Comparative notes : Its very small size and dark colour will serve to distinguish it from the other species dealt with here.

Distribution : Australia.

Habits : In stored tobacco in Australia (Belon, 1897).

Corticaria elongata (Gyllenhal).

Latridius elongata, Gyll., Ins. Suecica, 1 (4), 1827, p. 130.

♂. Length, 1.3-1.8 mm. Body elongate, subparallel-sided, moderately feebly convex. Cuticle shining and moderately pale reddish-brown ; antennae and legs paler and frequently brownish-testaceous. *Head* with punctures not more than two-thirds as coarse as facets of eyes, round, moderately shallow, and separated by one to two or sometimes more than two diameters ; surface between punctures sparsely, microscopically alutaceous, but in some specimens the alutaceous microsculpture is denser, more evident, and reticulate. Eyes large, strongly convex, nearly round (vertical diameter only slightly greater than horizontal, 5 : 4) ; head behind dorsal part of eyes without temples, but behind ventral caudal part of eyes with short but distinct temples. Antenna with segments 8, 9 and 10 about as broad as long. *Pronotum* with broadest point, which is well before middle, distinctly broader than long (0.49 : 0.41 mm.). Sides feebly rounded in front and slightly convergent behind ; lateral margins everywhere serrate, but much more coarsely and distinctly so near base. Base in front of scutellum with depression oval, slightly longer than apical segment of antenna and moderately shallow. Surface of disk with punctures round, moderately shallow, distinctly finer than facets of eyes, only slightly coarser than those of head, and separated by one to two or more diameters ; base and sides with punctures distinctly coarser and denser ; surface between punctures with a dense alutaceous microsculpture which is feebly transverse to reticulate. *Elytra* nearly three times as long as pronotum (1.18 : 0.41 mm.) ; base slightly narrower than broadest point of pronotum ; sides nearly parallel. Basal half of disk with punctures much coarser than those of pronotum, deep, round to subquadrate, one-third to one-half as broad as intervals, and separated longitudinally by one-half to slightly more than one diameter ; each interval with a single irregular row of microscopic punctures which are seldom more than a third as coarse as stria punctures and are separated longitudinally by three to four diameters. Pubescence moderately dense, more or less decumbent, and subequal. *Metasternum* with discal punctures shallow, microscopic (about one-third as coarse as facets of eyes), and separated by five to ten diameters ; anterior part of disk with punctures coarser and separated by one to two diameters ; surface between punctures microscopically, densely, reticulately alutaceous. Abdomen with sternite 5 not depressed and much longer than 4. *Legs* with basal segment of front tarsi feebly dilated. Front and middle tibiae each with a fine but conspicuous tooth on inner side near apex.

♀. Externally similar to ♂ but with basal segment of front tarsi not dilated and without a tooth on inner apex of front and middle tibiae.

Comparative notes : This species is closely related to *C. serrata* from which it may be distinguished as follows : (1) pronotum with anterior sides very finely instead of coarsely serrate ; (2) punctures of anterior half of pronotal disk seldom or never as coarse as facets of eyes and usually separated by one to two or more diameters, whereas in *C. serrata* these punctures are distinctly coarser than facets of eyes and are seldom separated by as much as one diameter ; and (3) discal elytral intervals each with an irregular row of sparse punctures which are seldom more than a third as coarse as stria punctures, whereas in *C. serrata* each discal interval has a much more regular and denser row of punctures which near base are almost as coarse as stria punctures and on middle of disk are at least half as coarse as stria punctures.

Distribution : Cosmopolitan.

Habits: In haystack refuse, moss, etc. in Britain (Fowler, 1889); in vegetable detritus, at the foot of trees, etc. in France (Belon, 1897); on warehouse walls in Britain (Hayhurst, 1937); and in England in company with the ant *A. (D.) brunneus*, by beating faggots and lime trees, in dry fungus, loose hay, by evening sweeping, and abundant in haystack bottom (Donnithorpe, 1939).

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BATS AS A SOURCE OF FOOD FOR *GLOSSINA MORSITANS*
AND *G. TACHINOIDES*.

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Large numbers of the bat, *Nycteris hispida*, Schreber, have been observed at dusk flying out of the residual forest islands at Gadau. Some have been captured and placed in a large cage containing *Glossina morsitans* and *G. tachinoides*. The sleeping bats, hanging head downwards, are perfect complacent hosts; both species of tsetse have been seen to attack and feed on them on many occasions, and to experience no difficulty in becoming fully gorged.

In the heavy rains when floods force the game to evacuate the tsetse-infested river-plain, it is possible that bats form a very important source of food, especially for *G. tachinoides* which is much less inclined to wander from the forest islands, and which, incidentally, is always the better-fed species (Nash, Bull. Ent. Res., **28**, 1937, p. 35).

KEYS TO THE MUSCIDAE OF THE ETHIOPIAN REGION:
SCATOPHAGINAE, ANTHOMYIINAE, LISPINAE, FANNIINAE.

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In the British Museum (Natural History) Ruwenzori Expedition 1934-35 vol. II nos. 3 (1939) and 4 (1940) generic keys to the MUSCINAE and COENOSIINAE and specific keys to *Graphomyia*, *Musca* and the COENOSIINAE of the Ethiopian region have been published. As there seems no possibility of the Museum issuing any more of these reports in the near future, it has been agreed that suitable extracts from the manuscript of the third part be published in this Journal, so that the keys and some other necessary data shall be available for the use of Entomologists in Africa.

The SCATOPHAGINAE are dung-eaters as larvae and prey on small Diptera, etc., as adults. The biology of the ANTHOMYIINAE is very varied, though that of the Ethiopian species has been explored only to a small extent. *Hylemyia cilicrura*, Rond., is omniphagous, as elsewhere in the world; it has been found in S. Rhodesia damaging potatoes, Kaffir corn (*Sorghum*) and beans (Cuthbertson, 1936, Occas. Pap. Rhodesian Mus. **5**, p. 57), and in Morocco attacking egg-pods of locusts (Regnier, 1931, Invas. Acrid. Maroc, Rabat, **3**). *H. andersoni*, Mall., and *arambourgi*, Ség., have been bred, according to labels in the collections at hand, from stems of rapoko (*Eleusine coracana*) in S. Rhodesia by Mr. A. Cuthbertson, and *H. metatarsata*, Stein, from leaves of *Lobelia satimae* by G. L. R. Hancock. The labels on the material of *Anthomyia griseobasis*, Mall., refer to damage done to ripe coffee-berries (see Le Pelley, 1932, J. E. Afr. Uganda Nat. Hist. Soc. **40-41**, pp. 67-77), *Warburgia* (van Someren) and vegetable marrow (T. J. Anderson). The adults of the LISPINAE are useful from the medical point of view, as they prey largely on the different stages of CULICIDAE (Lamborn, 1920, Bull. Ent. Res. **11**, p. 279; Evans, 1930, Trans. Ent. Soc. London **78**, p. 325; Cuthbertson, 1937, Trans. Rhodesia Sci. Assoc. **35**, p. 23). Some of the species of *Fannia*, on the other hand, may be expected occasionally to cause intestinal and cutaneous myiasis, as in Europe.

Species marked with an asterisk(*) have been incorporated from the literature, as no specimens are available.

Literature and synonymy are only mentioned so far as they are not contained in Ségué (1937, Gen. Ins. fasc. **205**, Muscidae) or when the former is directly referred to.

The first two connate abdominal segments are counted as one, so that the last entirely free tergite is the fourth. Abbreviations used in describing the legs: *a* anterior; *ad* antero-dorsal; *av* antero-ventral; *d* dorsal; *p* posterior; *pd* postero-dorsal; *pv* postero-ventral; *v* ventral. In using these expressions the leg is imagined as being extended in a straight line at right angles to the longitudinal axis of the body.

Other abbreviations:

<i>acr</i> ... acrostichal bristles (hairs)	<i>prsc</i> ... prescutellar
<i>dc</i> ... dorsocentral bristles	<i>prst</i> ... presutural
<i>h</i> ... humeral cross-vein	<i>R</i> ₅ ... first posterior cell
<i>ia</i> ... intraalar bristles	<i>r</i> ₁ ... first vein
<i>m</i> ... fourth vein	<i>r</i> ₄₊₅ ... third vein
<i>m-m</i> ... posterior cross-vein	<i>r-m</i> ... small cross-vein
<i>ph</i> ... posthumeral seta	<i>sa</i> ... supraalar bristle
<i>post</i> ... postsutural	<i>sc</i> ... auxiliary vein
<i>pra</i> ... prealar bristle	<i>stpl</i> ... sternopleural bristles.

The types of all the new species are in the British Museum (Natural History).

Key to the Subfamilies.

- 1(14). Lower calyptra rounded at apex, its inner margin more or less diverging from scutellum from base to apex, its outline semicircular to subtriangular. (If the apex is very broadly rounded and the basal part of the inner margin lies rather close to scutellum for a short distance, the arisal hairs are present on dorsal surface only and branched: *Glossina fusca* group.)
- 2 (5). Sixth vein reaching (at least as a fold) or nearly approaching margin of wing; in the latter case always, and in the former as a rule, the ventral surface of scutellum with fine erect hairs, these being much finer and much more erect than the hair on the dorsal surface.
- 3 (4). Five (six, if the basal two fused segments are counted separately) free pregenital tergites in both sexes, the last of them haired like the last but one, in the male therefore six (seven) tergites in front of the strongly convex second genital segment. Only one *stpl* (in *Scatophaga*). Frons without cruciate setae, in male as wide as in female.....SCATOPHAGINAE: *Scatophaga*
- 4 (3). Four (five) pregenital tergites in both sexes, seldom five (six) visible, but then the last one (*i.e.*, the last but one before the strongly convex second genital segment), not haired, though sometimes with marginal setae. At least two *stpl*.....ANTHOMYIINAE
- 5 (2). Sixth vein never reaching margin of wing. If the scutellum bears any hairs on ventral surface, these are of the same kind as those on dorsal surface, sides and apex of scutellum.
- 6(13). Proboscis with the mentum weakly or moderately sclerotized and shorter than head, not strongly tapering to apex, with labella. Pteropleura bare or hairy, in the latter case either vein *m* more or less straight, or the body strongly metallic, or the palpi spatulate.
- 7 (8). Hind tibiae with a strictly dorsal seta beyond middle (in exact alignment with the *d* preapical). Seventh vein strongly curved outward, almost always somewhat sigmoid and its apex bent round the apex of the short sixth vein; the two veins would by further extension always meet in a point before reaching hind margin. *sc* straight from shortly beyond *h* to the costa. Parafacialia often setulose, especially in female.....FANNIINAE
- 8 (7). Hind tibiae often with *pd* or *ad* setae or both, but never with a strictly dorsal seta besides the *d* preapical. Seventh vein less strongly curved, the sixth and seventh would by further extension never meet in a point before reaching the hind margin.
- 9(10). Pteropleura with a tuft of fine, erect hairs on lower part, immediately above the posterior *stpl*, in the middle between lower anterior end of infrasquamal ridge† and pteropleuro-sternopleural suture, but without hairs on upper half. Parafacialia almost always setulose. Palpi more or less strongly depressed and dilated at apex. Frons in both sexes about one-third of head-width, with two pairs of reclinate or outwardly curved upper frontals, and without a pair of cruciate interfrontals.....LISPINAE

† The supraspiracular convexity (above the posterior thoracic spiracle) is separated from the pteropleura by a conspicuous depression. Above this depression they are connected by an elongate-triangular ridge which is broader and flattens out at the pteropleural end; this ridge is here named the *infrasquamal ridge*. The middle part of the supraspiracular convexity is connected with the upper hind end of the sternopleura by an embossed part of the hypopleura, which is rather similar in shape and direction to the infrasquamal ridge; it has recently been named *beret* (*barrette*) by Mesnil (1939, *Essai s.l. Tachinaires*, Paris, p. 10).

- 10(9). Pteropleura bare or haired, but in this case the hairs only or mainly on upper part, especially on the infrasquamal ridge. Parafacialia almost always bare. Palpi sometimes slightly clavate or slightly depressed and dilated at apex.
- 11(12). Frons of both sexes of equal width and at narrowest point at least a seventh the width of head, the reclinate setae not bent outward, one or two present and conspicuous; if two, the anterior one rather widely separated from the posterior and *stronger* than it. Never more than one strong (or 2-3 weak, or one moderate and one strong) *prst dc* and three strong (sometimes 2-3 weak and 1-2 strong) *post dc* present. Generally three *stpl* in a more or less equilateral or at least not very elongate triangle. Veins always wholly bare (except, of course, costa).....COENOSIINAE
- 12(11). Frons of male usually much narrower than that of female, in dichoptic males and in females with two reclinate setae, which are at the same time more or less bent outward, the anterior one rather close to the posterior and *weaker* than it PHAONINAE
- 13(6). Proboscis with the mentum heavily sclerotized and at least as long as head, usually much longer than it, almost always strongly tapering to apex, without labella, but usually with conspicuous prestomal teeth. Pteropleura hairy. Vein *m* always broadly rounded forward about middle of apical section or just beyond *m-m*.....STOMOXIDINAE
- 14(1). Lower calypttra broadly truncate at apex, its inner margin lying close to scutellum from base to near apex, its shape inverted-triangular to trapezoidal. Aristal hairs never branched. Proboscis with the mentum shorter than head. Vein *m* more or less, usually strongly, bent forward in apical part. (Other characters as in Phaoninae).....MUSCINAE

SCATOPHAGINAE.

I know of no satisfactory character for distinguishing this group from the other MUSCIDAE, though it has formerly even been included in the acalyptrate series as a special family. All its characters are, of course, those of the Calyptrata. The interrupted mesothoracic suture does not distinguish the SCATOPHAGINAE from many ANTHOMYINAE which have the suture quite as distinctly interrupted in the middle. Moreover, in individual SCATOPHAGINAE the suture is not seldom complete. Genera with dichoptic males and without cruciate interfrontal setae are found in most of the other subfamilies, including ANTHOMYINAE. The abdomen is in *Scatophaga* and most other genera† somewhat more primitive than in many of the other MUSCIDAE, as the tergites after the fourth (fifth actual tergite) are somewhat more developed, but this is not the fundamental difference indicated by the words "six pregenital segments" against "at most five" (e.g. Sack 1937, in Lindner, Flieg. pal. Reg. **112**, pp. 4, 8). In the male two distinct, complete, narrow tergites can be seen between the fourth (fifth) tergite and the convex basal part of the hypopygium, but exactly the same condition is found in ANTHOMYINAE with the only difference that in the latter group the fifth tergite is often completely hidden under the fourth and that it is not hairy, so far as I know.

From the Ethiopian region two *Cleigastra*‡ and seven *Scatophaga* have been described (besides *S. helenae*, Thoms., from St. Helena). *Cleigastra subnigripes*,

† Besides *Cleigastra*, Macq. (= *Chidogastra*, auct.) the males of *Americina vittata*, Mg., and *Leptopa filiformis*, Zett., have been found by Mr. J. E. Collin and myself to have only four pregenital segments.

‡ *Cleigastra* would in the present paper be traced to *Pegomyia*, from the typical forms of which it is distinguished by the *pv* apical spur of the hind tibiae and the dichoptic male, whereas the first two species of *Pegomyia*, contained in the present paper, are separated from *Cleigastra* by the presence of cruciate interfrontals.

Karsch, however, has proved to be an *Atherigona*, and there is in my opinion little doubt that *Cleigastra longicornis*, Macq. 1843 (♀) is the species known as *Anaphalantus pennatus*, Loew (Coenosinae), which would have to assume the former specific name, if the type confirms my view; the description fits exactly, but the figures are at variance with the description as well as with my interpretation. The present subfamily is thus obviously represented by the single genus *Scatophaga*.

All the specimens that I have seen from the Ethiopian region have the antennae fuscous-black, the arisal hairs rather long (the longest rays more than half as long as the third antennal joint is wide), the pteropleura haired, and the hind tibiae with eight or more *ad* and *pd* setae. All of them would therefore be traced to *stercoraria* in Malloch's (1935, Ann. Mag. N. H. (10) **15**, p. 244) as well as Sack's (1937, Cordyluridae in Lindner, Flieg. pal. Reg. **112**, p. 48) keys.

S. hottentotta, Macq.,† is obviously a synonym of the variable *stercoraria*, and Macquart himself (1843, Mém. Soc. R. Lille, **1842**, p. 342; Dipt. exot. ii, 3, p. 105) doubts whether his form is more than a variation. *S. capensis*, R.-D., may be the same, but the description is very poor, and the words "pattes jaunes avec quelques taches brunes" especially are rather obscure. *S. soror*, Wied., is said to be almost identical with *scybalaria*, "F.", but Fabricius distinguished this species from *stercoraria* only by the coloration of its body, without mentioning the difference in the colour of the antennae (and, of course, in the hairiness of the pteropleura). I think *soror* refers to fulvous specimens of *stercoraria*. All the *S. African Scatophaga* I have seen so far belong to the latter species.

Key to the Ethiopian Species of *Scatophaga*.

- 1 (4). *r-m* without a dark suffusion, at most the vein itself somewhat darker.
- 2 (3). Wings strongly tinged with brownish-yellow. The longest rays of the arista almost as long as the diameter of the third antennal joint. ♂: Apical half of inferior forceps only slightly sigmoid; posterior claspers somewhat larger than anterior ones, slightly falciform; paramedian processes of fourth ventrite separated by a wedge-shaped incision, evenly clothed with fine, moderately short hairs. ♀: Sixth and seventh abdominal tergites transversely convex, polished black with only some cinereous dust on ventral part of sixth.....*socia*, Beck.
- 3 (2). Wings greyish hyaline or with a slight fuscous tinge. The longest rays of arista hardly two-thirds as long as the diameter of the third antennal joint. ♂: Apex of inferior forceps strongly bent up (dorsad and forward); posterior claspers slender, not stouter than the anterior ones, straight; paramedian processes of the fourth ventrite separated by a parallel-sided incision with pointed base, clothed with long, fine hairs along outer edge and with very short spinulose hairs at apex. ♀: Dorsum of sixth abdominal segment depressed, ferruginous, seventh tergite ferruginous to piceous.....*stercoraria alata*, Beck.
- 4 (1). *r-m* with a fuscous suffusion, *m-m* usually slightly infuscate.

† I wish to give my thanks to Mr. J. E. Collin for the following information: "The specimens of *Scat. hottentotta* in Bigot's Collection, named by Macquart, are evidently a form of *stercoraria*, differing chiefly from our British *stercoraria* and *merdaria* in having the end of the femora more broadly yellow, and in the presence of a strong posterodorsal bristle (or spine) near end of hind femora. They also have some dark bristly hairs on hind margins of, at least some, abdominal segments as in our var. *merdaria*." The Ethiopian specimens at hand are variable with regard to the first and last of these characters, but with very few exceptions, mostly from Mt. Elgon, they have a distinct *pd* preapical on at least one of the hind femora, usually a strong one on both. In one of the Elgon specimens this seta is quite well developed, in another just distinct. In *socia* it is entirely absent, as in British *stercoraria*.

- 5 (6). Femora blackish, at least at base, the apex more or less pale. Genitalia ♂♀
as in ssp. *alata*.....*stercoraria*, L.
- 6 (5). Femora pale, the apex of the posterior pairs blackened. (Cape).....
* *merdivora*, R.-D.

ANTHOMYIINAE.

Whereas in Europe this subfamily is the largest of the MUSCIDAE and is only more or less equalled in numbers by the PHAONIINAE, both containing about four times as many species as the next largest subfamily, it is well known that in the southern hemisphere the ANTHOMYIINAE are poorly represented (see Malloch, 1934, Dipt. Patagonia S. Chile **7**, 2, p. 172). In the Ethiopian region they are approximately reached by the STOMOXYDINAE (including *Glossina*) and outnumbered by MUSCINAE, COENOSIINAE and particularly PHAONIINAE, both the latter groups being several times as numerous in species as the ANTHOMYIINAE.

The outstanding character of the subfamily is the long sixth vein which reaches (or, in a few genera, almost reaches) the margin as a fold. The scutellum bears fine, erect, short hairs on the ventral surface in the forms here dealt with, except *Fucellia*, which is regarded as a somewhat isolated genus of the present group, and a few other ANTHOMYIINAE (*Pegomyia obscurinervis*, sp. n., and *Antholimna*, g. n.).

Several authors have divided the ANTHOMYIINAE into two tribes based on the holoptic and dichoptic males respectively. Species like *Hylemyia eurymetopa* and *edwardsiana* and *Eustalomyia africana* are, however, so closely related to other species of these genera that the systematic importance of the width of the male frons is entirely discredited. Generally speaking, the habit of distinguishing flies by striking characters of the males tends to obscure the systematic relationships, and an attempt has, therefore, been made at classifying the Ethiopian genera of the group in the following key by characters present in both sexes.

Key to the Ethiopian Genera of Anthomyiinae.

- 1 (14). Hind tibiae with not more than one or two *pd* setae (very seldom, individually, with three, but then the propleural depression with erect hairs). Ventral surface of costa always distinctly haired between *h* and *r*₁, if hind tibiae with more than one *pd*.
- 2 (3). One *prst* dc. Eyes broadly separated in both sexes (but the frons not equally broad). Propleural depression and pteropleura bare. Lower calypttra much longer than upper one, strongly projecting. Ventral surface of costa distinctly hairy between *h* and *r*₁.....**Anthocoena**, g. n.
- 3 (2). Two *prst* dc.
- 4 (5). Ventral surface of costa bare. Hind tibiae with only one *pd* seta, which is very strong. Propleural depression and pteropleura bare. Prosternum large (setulose, and the hypopleura bare in the Ethiopian species: *fasciata*, Stein). Abdomen with broad, velvety-black transverse bands along front margins of segments, these bands produced backward on median line.....*Calythea*, Schnabl
- 5 (4). Ventral surface of costa distinctly haired between *h* and *r*₁. If only one *pd* is present on the hind tibiae, it is not markedly stronger than the other setae.
- 6 (7). Hind tibiae without a *pd* seta. Scutellum not ciliate on ventral surface. Sixth vein very distinctly reaching margin of wing.....**Antholimna**, g. n.

- 7 (6). Hind tibiae with one or two (seldom three) *pd* setae. Scutellum ciliate on ventral surface, except sometimes, when the hind tibiae have a *pv* apical spur.
- 8 (9). Hind tibiae with only one *pd* seta. Sixth vein not reaching margin of wing. **Ecliponeura**, g. n.
- 9 (8). Hind tibiae with two (seldom three) *pd* setae. Sixth vein reaching margin of wing.
- 10 (11). Pteropleura with 1-2 setae or a group of setulose hairs at the anterior end of the infrasquamal ridge.† Lower calyptra distinctly longer than the upper one, strongly projecting. Propleural depression almost always bare. The stronger *acr* more widely separated from each other than from the *dc* (in some males the two distances are equal), the space between the two stronger *acr* rows beset with smaller setulae.....*Emmesomyia*, Mall.
- 11 (10). Pteropleura entirely bare. Lower calyptra shorter than upper one, not or not very strongly projecting. The stronger *acr* at most as widely separated across median line as from the *dc*.
- 12 (13). Propleural depression with some fine, erect, black hairs (very seldom, individually, bare). Pollinosity whitish-grey, thorax with two black sometimes indistinct spots in front and a broad transverse band or three large spots behind suture, seldom with longitudinal vittae. Femora and tibiae usually wholly black, seldom partly, never entirely pale.....*Anthomyia*, Meig.
- 13 (12). Propleural depression bare. If an *Anthomyia*-pattern is developed, the femora and tibiae wholly testaceous.....*Pegomyia*, R.-D.
- 14 (1). Hind tibiae with more than two, usually three, *pd* setae, seldom, individually, with only two *pd*, but then the costa bare on ventral surface between *h* and *r*₁. Lower calyptra shorter than upper one, at most very slightly projecting. Propleural depression and pteropleura wholly bare.
- 15 (18). Scutellum with small, fine, erect, pale hairs on ventral surface. Costa bare or haired ventrad to the lower one of the two rows of spicules, but without a row of stout, small, widely separated spicules.
- 16 (17). Scutellum entirely black, or black with the base grey in middle (the grey middle part reaching apex in extralimital forms). Body with an *Anthomyia*-like pattern: pale grey dusted, thorax with one to three spots before suture and a transverse band or three large spots behind suture, the anterior and posterior median spots sometimes connected, but then the ensuing vitta is suddenly dilated behind suture; abdomen with a black median vitta and each segment with a black transverse band along front margin, which is usually produced backward on its outer ends. ♂: abdomen only slightly depressed, even in basal half, subcylindrical, fifth tergite black and glossy. Hind tibiae with a minute *pv* terminal spur.*Eustalomyia*, Kow.
- 17 (16). Scutellum brown or cinereous-grey or grey, sometimes darker in middle. Thorax often with three more or less dark and more or less broad, not suddenly dilated vittae, but without spots; abdomen often with a median vitta, but not with conspicuous black transverse bands on anterior margins.*Hylemyia*, R.-D.
- 18 (15). Scutellum bare on ventral surface. Ventral surface of costa from the apex of *r*₁ onwards with a row of stoutish spicules that are separated by distances equal to more than their length. Frons broad and with well-developed cruciate interfrontals in both sexes.....*Fucellia*, R.-D.

† See note p. 252

Anthocoena maculipennis, sp. n. ♂♀.

Length 4.5 mm. Black, densely grey dusted, with two pairs of brown vittae on thorax and an abbreviated median vitta in front of scutellum; second to fourth abdominal segments of male with faint, paired, brown spots, fifth with a more conspicuous median spot, abdomen of female with only single brown spots at the base of the setae. Palpi, antennae and legs black.

Head: frons without cruciate interfrontal setae; ocellars and inner verticals strong, outer verticals and postverticals not very strong. Third antennal joint four times as long as wide, not reaching mouth-margin, middle rays of arista almost half as long as third antennal joint. *Thorax*: *acr* in 4-5 irregular rows, 1+3 *dc*, 1 *post ia*, 3 *stpl* in an almost equilateral triangle. *Abdomen* of male subcylindrical, curved downward. *Legs*: fore tibiae with one *pv*, which in male is fine and long and not distinct from two rows of long erect hairs between it and apex; mid-tibiae without *av* or *pv*, but with two *pd* and, in female, two *ad* setae; hind tibiae of male with one strong *pd*, two strong *ad* setae and two *pv* setulose hairs, of female with a strong *av* and two strong *pd* and *ad* setae. *Wings* with spotted *r-m* and *m-m*, sixth vein not quite reaching margin, costal spine and spicules long.

KENYA: Mt. Kinangop.

Antholimna elgonia, sp. n., ♀.

Length 5.1 mm. Head fuscous, thorax light brown with paler shoulders, abdomen fuscous with ferruginous-translucent tip, body densely grey to cinereous dusted; thorax with two pairs of brown vittae, the paramedian ones diverging behind; abdomen with a pair of roundish brown spots on each segment. Palpi and antennae fuscous, coxae infusate, femora browned, rest of legs pale brown.

Head: Frons without cruciate interfrontal setae. Eyes with sparse, short hairs. Inner verticals and ocellars long, outer verticals, postverticals and the pair of occipitals conspicuous. Third antennal joint two and a half times as long as wide, not reaching mouth-margin, arista as wide, including plumosity, as third antennal joint. *Thorax*: *acr* in 2-3 irregular rows, 2+3 *dc*, 2 *post ia*, 1+2 *stpl*. *Legs*: fore tibiae with a *pv* and a small *ad* seta; mid tibiae with a strong *ad* and *pd* at middle and at apical quarter, and a strong *pv* at two-thirds; hind tibiae with two strong *ad* near middle and two *av* near apical third. *Wings* with spotted *r-m* and *m-m*, lower calyptra slightly longer than the upper one, conspicuously projecting.

KENYA: Mt. Elgon.

Ecliponeura spinicosta, sp. n., ♂♀.

Length 4.9-7 mm. Black, brownish-grey dusted, thorax with two pairs of vittae, the paramedian ones not reaching far beyond suture; abdomen only with some brown points at the bases of the strongest setae. Palpi, antennae and legs black, tibiae translucent dull reddish-brown.

Head: frons about one-sixth head-width in male, wide in female, without cruciate interfrontal setae. Eyes with sparse and short hairs. Verticals, postverticals and ocellars rather strong and long. Third antennal joint two and a half times as long as wide, not reaching mouth-margin, longest rays of arista as long as third antennal joint wide. *Thorax*: *acr* in about 6 irregular rows, 2+3 *dc*, 2 *post ia*, 3 *stpl* in an almost equilateral triangle. *Legs*: front tibiae with an *ad* and *pv* submedian seta; mid tibiae without *av* or *pv*, but with two *ad* and *pd* setae; hind tibiae with one *av*, two *ad* and one *pd* seta. *Wings* with spotted *r-m*, and *m-m*, costal spine and spicules very long; lower calyptra conspicuously projecting, longer than upper one.

KENYA: Mt. Kinangop and Nyeri Track.

Emmesomyia, Mall. 1917.

Rhodesina, Mall. 1921, Ann. Mag. Nat. Hist. (9) **7**, p. 424 (*n. syn.*).

The genus, as understood here, includes *Rhodesina*, Mall., and *Taeniomyia*, sensu Malloch. The type of *Rhodesina ignobilis*, Mall. (labelled by Malloch "*Rhodesina steynertoni*, Mall. Type") is in the B. M. Though the bristle typical of *Emmesomyia* is lost, its point of insertion is distinct at the ordinary place on both sides. The genus must, therefore, be transferred from the synonymy of *Hydrophoria* (Séguy, 1937, Gen. Ins., fasc. 205, p. 131) to that of *Emmesomyia*. The female type fits the description of Stein's *Taeniomyia ignobilis* very well, and the two species may be regarded as synonymous, so much the more as both forms were described from Chirinda Forest (see Malloch, *l.c.* p. 425).

Taeniomyia, Stein, was first published in connection with the description of *T. auricollis*, Stein (1918, Ann. Mus. nat. Hung. **16**, pars 1, p. 237, issued 30.viii.1918). In the same paper *T. collaris*, Wulp, and *semipellucida*, Stein, are mentioned as belonging to it. The description of the genus and a list of the species referred to it by Stein appeared only in 1919 (Arch. Naturgesch. **83**, A 1, p. 150, issued Febr. 1919). This list includes *fascigera*, Stein, but as this species does not occur in the first description of the genus, it is not available as genotype, and Malloch's fixation (1921, Ann. Mag. Nat. Hist. (9) **7**, p. 424) is therefore invalid. The genotype is, thus, *auricollis*, Stein, as fixed by Séguy (1937, Gen. Ins., fasc. 205, p. 141). I find no indication of Malloch having studied this species, and there is no specimen of it in the B. M. As Stein does not mention the single seta or group of hairs on the pteropleura in his descriptions, it is doubtful whether this character applies to the genotype, whereas of the species at hand, *flavipalpis*, Wulp, has the single seta of *Emmesomyia*, and *collaris*, Wulp, has no trace of any hairs or setae on the pteropleura. In one of the specimens of *fascigera* in the B. M., identified by Malloch, only two hairs are present on the pteropleura, and again, in typical *Emmesomyia* there are sometimes two smaller setae present on one side instead of the one strong seta. Obviously, transitions occur, and it seems best to include *Taeniomyia*, sensu Malloch, with the Ethiopian species *fascigera*, Stein, and probably the Buru species *nigrithorax*, Mall., in *Emmesomyia*, leaving the question of the neotropical genus *Taeniomyia*, Stein, out of this paper.

The species, except for *setinervis*, *micans* and *tarda*, have a pattern similar to that of *Anthomyia*. A key to five Ethiopian species was published by Malloch (1924, Ann. Mag. Nat. Hist. (9) **14**, p. 260). I have seen eleven species, including *Hydrophoria setinervis*, Stein, of which I have only studied a somewhat aberrant East African specimen. Few structural characters serving to distinguish the species have been found.

Key to the Ethiopian Species of Emmesomyia.

- 1 (6). Pteropleura with a group of setulose hairs on the anterior end of the infrascapular ridge. Outer *ph* absent or very fine. Front femora almost entirely piceous, mid-femora at least largely piceous.
- 2 (3). Propleural depression with erect, black hairs. *acr* rows of male more distant from each other than from *dc*. Legs very slender and long in male. Presutural spots not connected with the postsutural band. Wings greyish hyaline. 6.4 mm. Uganda.....*propleuralis*, sp. n. ✓
- 3 (2). Propleural depression bare. *acr* rows of male equally distant from each other and from *dc*.
- 4 (5). Wings yellowish-smoky, the base and costal and sub-costal cells strongly yellowish tinged. Legs very slender and long, particularly the hind ones. Presutural spots connected interiorly with the postsutural band. Pleurae light brown in ground-colour (mature?), pollinosity of mesonotum pale golden. 7.2 mm. Uganda: Ruwenzori.....*longipes*, sp. n.

- 5 (4). Wings greyish hyaline. Legs normal. Presutural spots entirely separated from postsutural band by a transverse band of pale dust. Pleurae black in ground-colour, pollinosity of mesonotum silver-grey...*fascigera*, Stein
- 6 (1). Pteropleura with a single strong seta, seldom with two setae.
- 7 (12). Thorax rufous-brown, this colour being particularly conspicuous to the outer side of the *dc*, with an infuscated median vitta and the space between the *dc* broadly cinereous dusted. Scutellum translucent testaceous. Femora and tibiae entirely pale testaceous. Abdomen yellowish-brown with or without narrow, dark hind marginal bands. Outer *ph* absent or indistinct.
- 8 (9). r_{4+5} setulose almost up to apex. Arista plumose. Thorax with a black median vitta. Hind tibiae with two *ad* setae.....*setinervis*, Stein
- 9 (8). r_{4+5} bare, except usually for a few small setulose hairs at base. Arista short-plumose. Median vitta of thorax brown to fuscous.
- 10 (11). Hind tibiae with two *ad* setae.....(n. syn. *africana*, Mall.) *micans*, Stein
- 11 (10). Hind tibiae with three *ad* setae.....*tarda*, Stein
- 12 (7). Thorax dark brown, at least between the *prst dc*, *ph* and *prst* and the *post dc* and *sa*.
- 13 (14). Femora and tibiae wholly pale, the hind tibiae and dorsum of apex of femora sometimes slightly infuscated. ♀: pattern of mesonotum distinct, palpi testaceous, scutellum and dorsum of abdomen (except on first segment) largely fuscous, though densely cinereous dusted. ♂: like female, or mesonotum largely cinereous dusted, dark pattern therefore vestigial, palpi fuscous, abdomen largely to entirely testaceous with narrow, fuscous hind marginal bands.....*ignobilis*, Stein
- 14 (13). Posterior femora largely infuscated, or with at least the apical quarter to fifth fuscous. Palpi fuscous in both sexes. Presutural spots well separated from postsutural band by a transverse band of grey dust, postsutural band often more or less divided along the *dc* by grey to brown pollinosity.
- 15 (18). Outer *ph* fine, hardly stronger and not much longer than the surrounding hairs. The two rows of stronger *prst acr* more widely separated from each other than from *dc*. Abdomen of male elongate, second and third segments less than twice as wide as long, first to third ventrites very elongate, the first at least twice as long as wide, the second almost as elongate. 5.5-8 mm.
- 16 (17). Mid and hind femora with a testaceous basal and a fuscous to black apical part of variable proportions, which are very different in colour though not sharply defined from each other.....*nigrolutea*, Mall.
- 17 (16). Mid and hind femora brownish testaceous at base, very gradually more infuscated to middle and apex, thus not obviously bicolorous.....*maculithorax*, Stein?, Mall.
- 18 (15). Outer *ph* rather strong, much stronger and longer than the surrounding hairs. The two rows of stronger *prst acr* as distant from *dc* as from each other (♂ only?). Abdomen of male rather short, second and third segments more than twice as wide as long. Mid and hind femora largely infuscated, but becoming gradually paler at base, the pale part not well defined. (Females unknown.)
- 19 (20). 6 mm.† ♂: first and second ventrites much longer than wide, setae of third and fourth ventrites rather appressed and rather short, only those towards the sides longer.....*natalia*, Mall.*

† The type of *natalia* is 6 mm. long, not 5, as stated in the description.

- 20 (19). 3.5 mm. ♂: first and second ventrites only slightly longer than wide, apical half of third and basal half of fourth with numerous, long, erect, somewhat curved setae. Natal.....*marshalli*, sp. n.

Anthomyia, Meig.

The haired propleura is a good outstanding character of this genus, but I have seen single specimens of several of the more common species in which no hairs are present on the propleura. In a similar way a few specimens of *fasciata* have a small third *pd* seta between the base and the proximal *pd*.

The Ethiopian region is richer in species of *Anthomyia* than any other part of the world. Malloch's key (1924, Ann. Mag. Nat. Hist. (9) **14**, pp. 267-269) contains all the Ethiopian species but *amoena*, Macq., and *singularis*, Stein, which were unknown to him. *A. procellaris*, Rond., and *pluvialis pluvialis*, L., probably do not occur in the Region but have been included in the key, as the former has been reported from it, and as the latter is regarded as conspecific with the Ethiopian *tempestatum*.

Key to the Ethiopian Species of Anthomyia.

- 1 (2). Thorax with three broad blackish-brown longitudinal vittae, the lateral ones from the *ia* and *sa* to the first *prst dc* and *ph*, indistinctly connected in front, the median one between *dc* bifurcate in front of suture, and its two branches enclosing an oblong spot of whitish-grey pollinosity and coalescing with the front end of the lateral vittae. Scutellum black, except for middle and apex. Costal spine at least as long as *r-m*. Longest hairs of arista distinctly longer than its basal diameter.....*singularis*, Stein
- 2 (1). Thorax with or without a pair of presutural spots and with a postsutural transverse band, which may be dissolved into 3-5 spots.
- 3 (12). Longest hairs of arista much longer than its basal diameter, arista long and slender, the thickened basal part gradually tapering.
- 4 (5). Base of posterior femora and the fore coxae testaceous, tibiae usually more or less pale brown translucent. Costal spine small, hardly half as long as *r-m*. Presutural spots not passing second *prst dc* and often abbreviated in front.....*ornata*, Big.
- 5 (4). Femora wholly dark, fore coxae usually black in ground-colour. Tibiae black.
- 6 (7). Costal spine at least as long as *r-m*, the spicules on the costa also rather long. Scutellum wholly black or with the apex narrowly grey. Arista, including plumosity, about as wide as third antennal joint. Wings with a strong yellowish-smoky tinge*spinigera*, Mall.
- 7 (6). Costal spine and spicules small or minute, the former up to about one-half as long as *r-m*.
- 8 (9). Presutural spots reaching second *dc*. Base of scutellum as a rule narrowly grey (except sometimes in male), apex with a grey spot, which tends to enlarge itself along median line. Postsutural transverse band broad, hind margin with several sinuations. Prescutellars of male very long, longer than the strongest *prst acr*.....*griseobasis*, Mall.
- 9 (8). Presutural spots not reaching second *dc*, often indistinct. Base of scutellum wholly black. Postsutural transverse band rather narrow with rather evenly convex front margin and rather evenly concave behind.

- 10 (11). First and second abdominal segments largely translucent in both sexes. Apex of scutellum grey, but the grey spot as a rule encroaching more broadly upon the sides, the black basal patch thus usually halfmoon-shaped *fasciata*, Walk.
- 11 (10). Abdomen entirely black in ground-colour. The apical grey patch of scutellum square, receding on sides, the basal dark patch thus pointed behind at either side *amoena*, Macq.
- 12 (3). Longest hairs of arista at most as long as its basal diameter.
- 13 (18). Arista of normal length, slender, the thickened basal part gradually tapering, arista with short hair, which is approximately as long as the basal diameter of arista. Outer end of the postsutural band or of the outer pair of postsutural spots broadly, seldom less broadly (*procellaris*), connected with the black mark at the base of the wing; if the connection is not much more than half as wide as the mesonotum between suture and anterior end of postalar callus, then the outer spots only shallowly emarginate at hind margin laterad of the posterior *ia*. Scutellum black with a small apical spot of pale dust (except sometimes in *procellaris* ♀, where it can be grey dusted with two lateral black spots).
- 14 (15). First and second abdominal segments largely testaceous. Presutural spots reaching front end of thorax; transverse postsutural band only very slightly produced on median line. ♂: lobes of fourth ventrite rounded at inner side of apex, without a process..... *abyssinica*, Jaenn.
- 15 (14). Abdomen wholly black, but largely whitish-grey dusted as usual. Postsutural transverse band with a short, broadly triangular anterior and a longer, truncate posterior extension in middle, the posterior extension delimited on either side by a rather deep excision of pale dust around the hind *dc*, which may be connected with the anterior pale dust. ♂: lobes of fourth ventrite with a conspicuous process at inner side of apex.
- 16 (17). Postsutural band only slightly narrower to base of wings, which it reaches rather broadly. Presutural spots somewhat abbreviated in front, the brownish-black pollinosity not reaching front end of thorax. ♂: lobes of fourth ventrite with a conspicuous, truncate production at the inner side of apex, which is directed forward (ventrad in morphological sense) (n. syn. *A. sensua*, Curr.) *benguellae*, Mall.
- 17 (16). Outer postsutural spots broadly produced backward and outward, obliquely joining the dark coloration on the ridge between postalar callus and base of wing. Presutural spots usually reaching front end of thorax. ♂: lobes of fourth ventrite with a distinct, rounded production at the inner side of apex, which is directed ventrad (caudad in morphological sense)..... *procellaris*, Rond.
- 18 (13). Arista short, rather suddenly incrassate at base, covered with microscopic pile, the longest hairs much shorter than the basal diameter. Outer postsutural spot or outer part of postsutural band free or connected only narrowly at hind end with the black mark at the base of the wing; if the connection is half or more than half as wide as the mesonotum long between suture and anterior end of postalar callus, then the outer part of the band (or spots) with a small but conspicuous angular excision at hind margin laterad of the posterior *ia*. Abdomen never partly yellowish. ♂: lobes of fourth ventrite slightly extended at inner side of apex, but without a distinct production *pluvialis*, L.
- 19 (20). Postsutural transverse band of thorax rather broadly divided by stripes of grey dust. Scutellum with two lateral black spots, or black with an apical spot of pale dust..... *pluvialis pluvialis*, L.

- 20 (19). Postsutural transverse band of thorax not or very narrowly divided by lines of grey dust, though more or less indented by the pale dust.
 Scutellum black with an apical spot of pale dust.....
pluvialis tempestatum, Wied.

Pegomyia, R.-D.

The Ethiopian species form two groups, the first of which is distinguished from the other Ethiopian and all the European species by the presence on the hind tibiae of a *pv* apical spur and may be entitled to generic rank. In the Ethiopian species cruciate interfrontal setae are always present in the female, the interfrontalia reddish to yellowish, the thorax entirely ferruginous or almost entirely piceous in ground-colour, and the abdomen mainly pale.

Key to the Ethiopian Species of Pegomyia.

- 1 (4). Hind tibiae with a *pv* apical spur. Occipital dilatation (the angular area on the jowls, on which the occipital row joins the peristomatal row) with some setulose hairs in addition to the row of setae.
- 2 (3). Arista short-haired, the longest hairs not longer than the basal diameter of arista. Costal spine as long as *r-m*. Thorax reddish, densely whitish-dusted, with a pair of narrow, brownish-yellow vittae along the *dc* to apex of scutellum. Abdomen wholly pale. Mentum, palpi, antennae, and tarsi testaceous. Parafacialia with a roundish, piceous spot at base of antennae. *r*₄₊₅, the following two longitudinal veins, and *r-m* and *m-m* infuscated, the latter two with a narrow, slight, fuscous suffusion. 3.3-3.5 mm. Gold Coast, Aden Protectorate*obscurinervis*, sp. n.
- 3 (2). Arista plumose, approximately as wide, including plumosity, as the third antennal joint. Costal spine indistinct. Thorax, including humeri, piceous, cinereous-grey dusted with a short, indistinct, brownish median vitta between the *acr*. Abdomen pale with a pair of dark brown spots at the base of the second to fourth segments. Mentum, palpi, antennae, tarsi fuscous. Parafacialia pale yellowish. Veins not infuscated.....*abdominalis*, sp. n.
- 4 (1). Hind tibiae without a *pv* apical spur. Occipital dilatation bare except for the row of setae. Arista short-plumose, not less than half as wide, including plumosity, as the third antennal joint. Costal spine indistinct. Abdomen pale or mainly pale, often with median, but not with paired spots. Tarsi more or less infuscated, usually piceous. Wings yellowish, veins pale. Thorax of male piceous, the humeri often paler translucent.
- 5 (6). Palpi, jowls and antennae yellowish to orange, the antennae somewhat infuscate on outer surface. ♂: scutellum wholly piceous. Thorax with a broad dark vitta on either side from front end to second *prst dc* and *prst* and a broad, transverse band or four large spots behind suture, the remainder greyish dusted, this dust being particularly conspicuous on a broad median vitta in front of suture, which is pointed anteriorly. ♀: thorax entirely ferruginous, a vitta on either side of the presutural part, between the *acr* and *dc*, is white-dusted in posterior view, and the humeri and notopleurae are yellowish dusted; upper two-fifths of occiput and frontal triangle, except for its apex, more or less strongly infuscated; frontal triangle glossy and large, with the apex rounded, fully reaching level of cruciate setae, longer than the distance from its front end to anterior margin of frons.
(n. syn. *insignis*, Stein) *tarsata*, Ad.

- 6 (5). Palpi and third antennal joint fuscous, the base of the antennae often dark orange, jowls brownish-red. Apex of scutellum testaceous translucent. Anterior dark vittae not very distinct, rest of mesonotum grey dusted, humeri often yellowish-translucent. ♀: scutellum and thorax as in male; occiput wholly fuscous; frontal triangle dusted, of moderate size, not reaching level of cruciate setae, nor longer than the distance from its front end to anterior margin of frons.....*luteiventris*, Rond. ††

***Pegomyia abdominalis*, sp. n., ♀.**

Length 3·7–5 mm.; *wings* 3·4–4·7 mm.

Head with the occiput, occipital dilatation and upper half of frons fuscous, rest of head dull yellow, the interfrontalia ochreous-yellow. Eyes broadly separated, frons a quarter wider than each eye, slightly dilated anteriorly, the parafrontalia a third the width of the interfrontalia behind, gradually and considerably dilated to front end, where they are wider than the interfrontalia, which in turn are considerably widened behind, parafrontalia with three inclinate, two proclinate and one reclinate frontal seta. Inner verticals strong, outer verticals rather strong, postverticals weak, ocellars and interfrontals well developed. Antennae fuscous, third joint twice as long as wide, passing level of lower margin of eyes and reaching mouth-margin which projects rather markedly, though not beyond level of anterior end of frons; arista rather suddenly thickened at base, plumose up to apex, the longest rays almost as long as the third antennal joint wide. Parafacialia half as wide, jowls one and a half times as wide as third antennal joint. Palpi fuscous.

Thorax wholly fuscous, densely grey dusted, with a brownish longitudinal suffusion between the *acr* on suture. *acr* small, in two rows, the *prsc* pair more or less conspicuously stronger; 2+3 *dc*, two *post ia*, *ph* and *prst* well developed, *pra* not much shorter than first *post dc* but only a third the length of *sa*; scutellum setulose, with two pairs of strong setae and a pair of smaller discal preapicals, ventral surface with fine, short, erect hairs. Upper propleural and prostigmatal setae moderately strong, lower ones weak, curved upward. Three *stpl*, the anterior one strong, the posterior one very strong, the lower one rather close to anterior *stpl* and much weaker. There is also a setulose hair or a small seta below and somewhat in front of the posterior *stpl*.

Abdomen ferruginous, rather densely golden-greyish dusted, second to fourth segments each with a pair of small, dark brown spots at base which are partly covered by the preceding segment. Each segment with a marginal row of setae, which are rather inconspicuous on the first but become gradually more conspicuous to the fourth segment, where they are quite strong.

Legs pale testaceous (the dorsum of the front femora, the apex of the posterior femora and the tibiae slightly infuscated in the smaller specimen), tarsi piceous. Front femora with 8–9 small *pr* and 6–8 small *pd* setae, which become slightly stronger towards apex, front tibiae with a rather small *pr* and a minute *ad* seta; mid-femora with two small *v* setae in basal quarter and an *ad*, *pr*, *p* and *pd* preapical, mid-tibiae with a small but rather stout *p* seta in middle, a *pd* at three-fifths and an *ad* at two-thirds; hind femora with two rather small *v* setae in basal third, a somewhat stronger *av* at three-fifths, an *av* preapical, 1–2 stronger *ad* and an *ad* preapical in apical

† The characters in the key are taken from specimens from Natal and S. Rhodesia. *P. luteiventris*, Rond. (♀) was described from Eritrea (Keren). It is said to be 6 mm. long, its palpi are "fusco-lutei," and *m-m* almost as far from *r-m* as from apex of fifth vein. The specimens at hand are only 4–5 mm. long, the palpi are fuscous, and *m-m* is almost twice as far from *r-m* as from apex of fifth vein. *P. ornata*, Bezzi (♂) is no doubt a synonym of *luteiventris*. It came from Eritrea (Adi Ugri); in the description the yellowish apex of the scutellum is not mentioned and the fourth abdominal segment is said to be black. The latter may be due to *post mortem* changes.

two-fifths, and a *pd*, *pv* and *p* preapical, hind tibiae with a small and a stronger *pd*, three *ad* which increase in length towards apex, and an *av* at two-fifths, apex with a distinct spur on *pv* surface.

Wings hyaline, the veins testaceous. Costal spine small, costa haired on ventral surface, the other veins quite bare. r_{4+5} and *m* very slightly diverging at apex, *r-m* conspicuously beyond level of apex of r_1 , in the type just beyond two-thirds, in the paratype just before three-fifths of discal cell. Calyptrae whitish-hyaline, lower one shorter than upper one, not projecting. Halteres pale yellow.

TANGANYIKA TERRITORY: Mbala, 26.ii.23, "seemed to be ovipositing in dung-ball of beetles" (A. Loveridge), ♀ type, 1♀ paratype (on one pin, the larger specimen is the type).

This species is probably closely related to *P. sexpunctata*, Karl (1935, Arb. morph. tax. Ent. 2: 45) from Transvaal. However, in *sexpunctata* the jowls are said to be almost one-half as high as the eyes (in *abdominalis* one-third), the base of the antennae reddish-yellow (in *abd.* entirely fuscous), the palpi yellow with infuscated apex (in *abd.* fuscous with the basal half of the dorsal surface slightly paler), the thorax yellowish grey with paler sides, and the *pra* weak. The abdomen seems to be identical. The size is 5-7 mm. It is curious that the *av* apical spur of the mid-tibiae should have been mentioned by Karl, but not the important (though smaller) *pv* spur of the hind tibiae, which has been used for defining major sections in *Hylemyia* by Collin and Ringdahl.

Eustalomyia, Kow.

As is obvious from the generic key (p. 256), *Eustalomyia* differs only very slightly from *Hylemyia* and is connected with the latter by *H. (Melinia) pullula*, Zett., and other *Hylemyia* with *pv* apical spur of the hind tibiae.

Key to the Ethiopian Species of Eustalomyia.

- 1 (2). Thorax with a complete, broad, transverse band, connecting the bases of the wings, behind suture, without a longitudinal vitta; presutural pair of spots small, sometimes fused. Outer *ph* absent. Parafacialia of ♂ without a black spot (though with dark reflections); eyes subcontiguous.....
griseopunctata, Mall.
- 2 (1). Thorax with three spots behind suture, which may be fused anteriorly, but which are separated at least behind by a long wedge of pale dust along the *dc*. The median postsutural spot approaching the scutellum, connected in front with a median vitta of the presutural part. Parafacialia of ♂ with a black spot at base of antennae.
- 3 (4). A strong outer *ph* present (above and somewhat before the anterior notopleural). Spots of thorax large, contiguous with the median vitta. Scutellum black, except for a narrow, grey-dusted basal margin. Eyes of male subcontiguous. 4-8 mm. Kenya: Mt. Elgon.....*guttata*, sp. n.
- 4 (3). Outer *ph* absent. Spots of thorax rather small, separated from median vitta. Scutellum broadly margined with black at sides and apex, a large basal triangle remaining grey dusted. Eyes of male broadly separated.....
africana, Ség.

Hylemyia, R.-D.

Though most of the Ethiopian species of ANTHOMYIINAE belong to *Hylemyia*, the paucity of species is nevertheless most marked in this genus. No attempt has been made at distributing the species over the subgenera created for European species. The

key is based on characters present in both sexes, but in a few cases (*arambourgi* and *andersoni*, *kigeziana* and *ventralis*) two closely related species can only be reliably separated by the characters of the male.

Key to the Ethiopian Species of Hylemyia.

- 1 (26). Mid tibiae without an *av* or with 1-2 very small *av* (shorter or not appreciably longer than the tibial diameter) beyond middle, in the latter case no distinct *pra* present, the latter is in any case much shorter than the first *post dc*.
- 2 (5). One or two minute *av* setae present at apical quarter or fifth of mid tibiae. No distinct *pra*. Hind tibiae without any or with only a single small *pv* setula among the appressed hairs, even in male. Dorsal surface of middle metatarsus and hind margin of second ventrite without a comb of setae in male. *m-m* not or slightly oblique, almost straight. Jowls about one-fourth of the eye-height.†
- 3 (4). Arista very distinctly pubescent, almost short-plumose, the longest hairs conspicuously longer than the basal diameter of arista; in ssp. *dispar*, Bezzi, the arista as wide, including plumosity, as the third antennal joint, and the thorax with a more distinct median vitta. Hind femora with about 4-6 long *av* setae, which are much (♂) or slightly (♀) longer than the femoral diameter and which are strong and evenly and slightly curved in male *flavibasis*, Stein
- 4 (3). Arista very short-pubescent, the hairs somewhat more distinct only near base, where they are, however, shorter than the basal diameter of arista. Hind femora with about 8-12 long, fine *av* setae, which in the male are much longer than the femora and are very fine and somewhat curled at apex *capensis*, Mall.
- 5 (2). Mid tibiae without any *av* setae. *pra* often very distinct. Hind tibiae of male usually with several outstanding *pv* hairs or setae, sometimes even the female with some.
- 6 (23). *m-m* not or hardly oblique, straight or slightly concave, not sigmoid. Mouth-margin only slightly produced, almost straight between the vibrissae. One *ph*. Base of wings and the calyptrae not bright orange.
- 7 (20). Wings unspotted. Hairs of ventral surface of costa absent or close to the spicules and, thus, on ventral part of *anterior* surface. Fifth abdominal segment of male densely dusted.
- 8 (13). Occiput with at most a few single setulae behind upper third of occipital row. Costa bare beneath the ventral row of spicules, at least in apical half of costal cell. Second ventrite of male without an erectile fan of setae; none of the setae of the fourth ventrite conspicuously longer than its lobes; if the *pv* surface of hind tibiae is densely ciliate in male, the *av* surface with only 2-3 outstanding setae.
- 9 (12). *pra* absent or hardly stronger than the hairs on lateral part of mesonotum. The two prostigmatal setae with at most 1-2 small hairs adjoining. None of the *prst acr* considerably stronger than the others. Jowls at least one-fifth of the eye-height.† Hind tibiae of male not ciliate on *pv* surface.
- 10 (11). Front tibiae normally with two rather small *pr* setae, one beyond middle, the other beyond three-quarters‡. ♂: lobes of fourth ventrite more or less horizontal and appressed, slightly narrowed from base to apex; penis shorter than inferior forceps, not very slender *arambourgi*, Ség.

† Jowls one-eighth to one-tenth of the eye-height, see *modesta*, Stein, p. 268.

‡ In two or three specimens this character varies on the two tibiae; it is therefore not entirely reliable, but I have not been able to find another distinction for the females.

- 11 (10). Front tibiae normally only with one rather strong *pr* seta beyond middle.†
♂: lobes of fourth ventrite vertical and erect, dilated from base towards apex; penis considerably longer than inferior forceps, very slender and rod-shaped. *andersoni*, Mall.
- 12 (9). *pr* well developed, though not long. The two prostigmatal setae surrounded by some fine hairs. One pair of *prst acr* much stronger than the others. Hind tibiae of male densely ciliate on *pv* surface. *cilicrura*, Rond.
- 13 (8). Occiput with a complete row of setulae behind upper third of occipital row. Costa with a distinct row of setulae beneath the ventral row of spicules at least to apex of costal cell. *pra* well developed (except sometimes in male), though not long. ♂ with an erectile fan of setae on apex of second (third) ventrite, or with very long curved setae on the lobes of the fourth (fifth) ventrite, some of which are almost twice as long as these lobes, or with ciliae on the *av* and *pv* surfaces of hind tibiae.
- 14 (15). Arista short, extremely short-pubescent, the longest hairs shorter than its basal diameter. Body dark brassy-brown, with brown dust, which forms a shifting brown pattern. ♂: hind tibiae ciliate on *av* and *pv* surfaces; *ad* surface with numerous setae; eyes separated by two-thirds the width of the third antennal joint. 3.5–4.6 mm. Kenya, Uganda.
bisciliata, sp. n. ✓
- 15 (14). Arista longer, distinctly haired, most of the hairs on its dorsal surface longer than the basal diameter of arista. Body densely cinereous-grey dusted with stripes of brown or dark brown dust. ♂: hind tibiae not ciliate, but with the normal setae; *pd* surface of mid tarsi with a distinct comb of half-erect setulae from base to beyond middle.
- 16 (17). Hind tibiae usually with three *av* setae. Thorax greyish-brown dusted with a rather narrow median and two broad lateral brown vittae, which are not very striking, usually with an additional pair of brown lines along the *dc*. ♂: first to third ventrites only with the normal erect hairs all over their surface, lobes of fourth ventrite with some very long, erect, bristly hairs, which are curved inward in their apical part and approximately twice as long as the other hairs of the abdomen. 4.1–5.3 mm. S.W. Uganda....
kigeziana, sp. n. ✓
- 17 (16). Hind tibiae usually with only two *av* setae. ♂: second ventrite with an erectile fan of long, strong setae near hind margin, lobes of fourth ventrite with stouter hairs, which are not longer than the other hairs of the abdomen.
- 18 (19). Thorax greyish-brown dusted with a rather narrow median and two broad lateral brown vittae, which are not very striking, often with an additional pair of brown lines along the *dc*. Longest hairs near base of dorsal surface of arista at most a third as long as the third antennal joint wide. ♂: apical part of inferior forceps narrow and somewhat sigmoid.
ventralis, Stein
- 19 (18). Thorax pale-grey dusted, with three striking, broad, dark brown vittae, the median vitta reaching the *dc* laterally and the apex of scutellum behind. Longest hairs near base of dorsal surface of arista half as long as the third antennal joint wide. ♂: apical part of inferior forceps less narrow, straight....(n. syn. *H. trivittata*, Stein 1914, nec Stein 1897) *virgithorax*, Stein

† See note ‡ on p. 265.

- 20 (7). Wings with conspicuous fuscous spots on the cross-veins *r-m* and *m-m*. Hairs of ventral surface of costa not very close to the ventral row of spicules, thus on *ventral* surface. *pra* well developed, though not long. Arista short-plumose, almost as wide, including plumosity, as third antennal joint. Hind tibiae with a *pv* apical spur. Fifth abdominal tergite of male glossy black, not dusted, fourth ventrite with an extension at apex that is directed posteriorly and upwards.....*pullula*, Zett.
- 21 (22). Thorax with three brown vittae, which are not very broad or very conspicuous, particularly in female. Infuscation of *m-m* not or only slightly and gradually dilated to front end, infuscation on *r-m* smaller, the very base of *r₄₊₅* fuscous, but no infuscation on wing-membrane between it and base of *m*.....*pullula pullula*, Zett.
- 22 (21). Thorax with three very broad and dark brown vittae in both sexes. Infuscation of *m-m* strongly dilated and roundish at front end, infuscation on *r-m* large and circular, a small but distinct infuscation on wing-membrane from base of *r₄₊₅* to base of *m*.....*pullula intensa*, Mall.
- 23 (6). *m-m* strongly oblique and sigmoid. Mouth-margin rather strongly produced, distinctly protruding and more or less rounded between vibrissae. Either two *ph*, or the base of wings and the calyptrae are bright orange to ferruginous. *pra* well developed though not quite half as long as the first *post dc*.
- 24 (25). One *ph*. Occiput with a row of setulae behind upper third of occipital row. Arista short-haired. Calyptrae and base of wings, including basicostal scale, bright orange to ferruginous, fringe of calyptrae golden-orange. Halteres pale orange. Mesonotum with three broad, dark brown vittae. ♂: fourth ventrite protruding, with numerous stout, pointed, spiniform setae. 4.0-5.2 mm. S.W. Uganda*aurisquama*, sp. n.
- 25 (24). Two *ph*, a rather strong seta being present between the humeral setae and the *prst*, somewhat nearer the latter. Occiput uniformly setulose behind upper third of occipital row. Arista practically bare. Base of wings, including basicostal scale, fuscous, calyptrae and their fringe whitish, the latter often partly fuscous exteriorly, halteres largely infusate. Thorax with a complicated shifting pattern. ♂: middle metatarsus with a comb of long, evenly curved, half-erect *pd* setae, which are at least half as long as the metatarsus; hind tibiae ciliate on *pv* surface.....*metatarsata*, Stein
- 26 (1). Mid tibiae with 1-2 conspicuous *av* setae beyond middle, one of which is usually more than twice as long as the tibial diameter. *pra* more than half as long, often fully as long, as the first *post dc*. Larger species with dark coloration. ♂: eyes never contiguous, distinctly to very broadly separated; abdomen rather broad, more or less narrowed to apex of fourth segment, the latter broadly truncate, fifth tergite with numerous long and strong, erect setae; fourth ventrite very densely covered with stiff, rather short, pointed setae.
- 27 (28). Fringe and border of upper calyptra and base of wings dark brown. *av* of mid tibiae and *pra* of moderate length, the *av* less than twice as long as the tibial diameter. Costa bare on ventral surface. Eyes of male separated by about half the width of the third antennal joint. 3.8-5.5 mm. Uganda: Ruwenzori.....*nyamgasana*, sp. n.
- 28 (27). Fringe and border of upper calyptra and base of wings yellow to orange. *av* of mid tibiae approximately twice as long as tibial diameter, *pra* as long as first *post dc* (which itself is very long).

- 29 (30). Costa conspicuously haired ventrad to the lower row of spicules. Mid tibiae with normally one *av* and two *ad*, *pd* and *pv*. A smaller but usually very conspicuous additional *ph* interiorly and anteriorly to the normal *ph*. The stronger pair of *prst acr* very conspicuous, more than half as long as the first *dc*. A small but normally very distinct *prst ia* present. ♂: eyes separated by less than width of third antennal joint. (pro *H. vittithorax*, Stein 1914, nec Stein 1908) *vitticollis*, nom. n.
- 30 (29). Costa bare ventrad to the lower row of spicules. Mid tibiae with two *av* and three *ad*, *pd* and *pv*, or the stronger *prst acr* less than half as long as the first *dc*. ♂: eyes as widely separated as those of female.
- 31 (32). Mid tibiae with one *av* and two *ad*, *pd* and *pv*. Only the normal very strong *ph* and no distinct *prst ia* present. The stronger pair of *prst acr* not very conspicuous. 4.8-6.2 mm. Kenya: Mt. Elgon..... *eurymetopa*, sp. n.
- 32 (31). Mid tibiae with two *av* and usually four *ad*, three *pd* and 2-4 *pv*. A smaller second *ph* anteriorly and interiorly to the normal, strong *ph*. A small, but usually distinct *prst ia* present. The stronger pair of *prst acr* conspicuous. 5.2-6.8 mm. Kenya: Aberdares..... *edwardsiana*, sp. n.

Hylemyia modesta, Stein.

I fail to recognise this species, and Malloch has not seen it either, though Stein had eight specimens from four localities, which would seem to mean that *modesta* is one of the more common forms. The lack of a *pra* would indicate one of the first four species of the present key, but all of them have the jowls at least a fifth as high as the eyes, whereas in *modesta* they are said to be one-eighth to one-tenth as high. The arista is said to be shortly but distinctly plumose, which would perhaps fit *flavibasis* but none of the others. The hind femora (probably only of the male) have a complete row of long and fine bristles on the *av* (? "externo-inférieur") surface in *modesta*, whereas only six rather strong and not hair-like setae are present in *flavibasis*.

LISPINAE.

Chaetolispa, Mall., and *Xenolispa*, Mall., are here treated as subgenera, so *Lispe* is the only Ethiopian genus of this subfamily. A short key to the species of the Region has been published by Curran (1937, Amer. Mus. Novit. **931**, p. 1).

Lispe draperi, Ség. (1933, Bull. Mus. nat. Hist. n. Paris (2) **5**, p. 122) from the Saharian Mountains ("source d'In Azaoua, Tassili de Timissao"), though collected at the border of the Ethiopian Region, belongs to the *tentaculata*-group and, therefore, is not likely to be found considerably south of its typical locality. In the present key it would probably be traced to *pygmaea*, from which the male differs by the process of the fore metatarsus. The species is not mentioned in Ségu's Muscidae (1937, Gen. Ins. **205**), and *L. bipunctata*, Ség. (1938, Miss. scient. Omo **4**, Zool. p. 369) was described after Ségu's list and Curran's key had appeared.

L. hirtibasis, Big., and *hottentota*, Big., are synonymous and are not LISPINAE but belong to the *Limnophora* group, according to Mr. J. E. Collin, who has been kind enough to give me this information from the types in his collection.

Key to the Ethiopian Species of Lispe.

- 1 (2). Only a single distinct *dc* (in front of scutellum). Front femora with only 1-3 short *pv* setae near apex. Only the posterior *stpl* present (the anterior one sometimes present as a setulose hair). (sbg. *Xenolispa*, Mall.)—Abdomen with a pair of white-dusted oblique lateral spots on segments 2-4. Palpi often and halteres fuscous. Legs mostly black; front tibiae with *pv*, mid tibiae with a *p* beyond middle (and often a second at 4/5), hind tibiae with *ad*. *niveimaculata*, Stein

- 2 (1). Always several *dc* well developed. Front femora with a series of *pv* setae.
- 3 (46). Parafacialia without strong setae, at most with some stronger setulae at lower end besides the setulose hairs, the strongest of these setulae at most half as long as the strongest peristomatal seta. (sbg. *Lispe*, s. str.)
- 4 (5). Femora, halteres and palpi yellow. *dc* ?+3. Front tibiae unarmed, mid tibiae with a *pd*, hind tibiae with an *ad*. r_{4+5} and *m* almost parallel, slightly converging at apex. 4.5 mm. (typ. loc. Willowmore, Cape Prov.)
.....**flavipes*, Stein
- 5 (4). Femora black (except sometimes for the extreme apex).
- 6 (17). Palpi black. The *prst dc* and anterior *post dc* more or less weak.
- 7 (8). The last four joints of the front tarsi reddish-yellow. (1)+(2+2) *dc*. Tibiae black. Front tibiae with *pv*, mid tibiae with *ad* and *pd*, hind tibiae with *ad*, *av*, and *pd*. Shining black, abdomen with 1-3 pairs of white-dusted spots on sides.....*kowarzi*, Beck.
- 8 (7). Tarsi wholly black.
- 9 (12). Front tibiae with a *pv* seta. 7-8 mm.
- 10 (11). 1+(1+2) *dc*. Halteres yellow. Mid tibiae with a *pd*, hind tibiae with *av*, *ad* and *pd* setae. Mesonotum and scutellum glossy black, dark-brown dusted with an indistinct median vitta. Second and third abdominal segments with a very large dark spot, only the margins grey dusted. Second joint of front tarsi (male) with a distinct small tubercle on anterior surface.....*tuberculitarsis*, Stein
- 11 (10). 2+4 *dc*. Halteres brownish. Mid tibiae with *ad* and *pd*, hind tibiae with *ad* and *pd* (or *av*?). Thorax and scutellum grey-dusted, abdomen grey-dusted with faint dark brown spots.....**candicans*, Kow.
- 12 (9). Front tibiae without a *pv* seta, mid tibiae with a *pd* seta, without *ad*, hind tibiae with *ad* and one other submedian seta. (1-2)+(2-3+2) *dc*. Halteres yellow. Front tibiae black.
- 13 (16). Hind tibiae without an *av* but with a *pd* seta. Front tibiae short-haired all over, front femora with the normal setae and hairs. Second to fourth abdominal segments each with a pair of conspicuous white-dusted dorso-lateral spots.
- 14 (15). Dorsum of abdomen mainly glossy black and thinly dusted. Mesonotum with a pair of thinly dusted greyish-brown paramedian vittae, which are separated by a median vitta of dark brown dust. Hind tibiae long and slender, without long hairs. Hind femora of male with several very long, stiff, erect hairs in basal half of *pv* surface.....*nivalis*, Wied.
- 15 (14). Dorsum of abdomen very densely cinereous grey dusted, the pollinosity reaching and partly surrounding the white spots. Mesonotum with a broad vitta of grey to brownish ochraceous dust which extends laterally to the *dc* and is only divided in front by two narrow vittae of thinner pollinosity. Hind tibiae not very slender, in male with a row of long, erect *ad* hairs from *ad* seta to apex and some rather long hairs on apical part of *a* and *av* surfaces. Hind femora of male without erect *pv* hairs in basal half.
.....*ochracea*, Beck.
- 16 (13). Hind tibiae with an *av* but without a *pd* seta. Front tibiae (male) with rather longer hairs on apical half of ventral surface, front femora (male, female) with numerous short, spinulose setae on ventral surface in addition to the normal setae and hairs. Abdomen grey-dusted with paired black spots on segments 2 and 3*armipes*, Beck.

- 17 (6). Palpi reddish or yellowish.
- 18 (37). *m* straight or slightly curved.
- 19 (30). Two *prst dc*. Halteres and tibiae yellow,† in *nana* the apical half of the front tibiae often infuscate.
- 20 (27). Mid tibiae with only a *pd* seta.†
- 21 (22). Two strong *post dc*, the anterior one distinctly closer to suture than to the posterior one. Front tibiae unarmed. Thorax grey dusted with five faint brownish longitudinal vittae. Abdomen grey dusted with paired, dark brown spots. Parafacialia with about three slightly stronger setulae near ventral inner end.....*biseta*, Stein
- 22 (21). 3-5 *post dc*, either three of the *post* pairs strong or only the last 1-2 strong, in this case the anterior strong one closer to the last *dc* than to suture.† Parafacialia without stronger setulae.
- 23 (26). Front tibiae unarmed. 4-5 mm.
- 24 (25). Three strong *post dc*. Hind tibiae with only an *ad* seta. Palpi only slightly dilated at apex, hardly $1\frac{1}{2}$ times as wide as third antennal joint. Abdomen grey dusted with or without faint paired brownish spots on second and third segments. Head grey dusted.....*pygmaea*, Fall.
- 25 (24). Only the last *post dc* strong. Hind tibiae with an *ad* and a *pd* seta. Palpi very strongly dilated at apex, almost thrice as wide as third antennal joint. Abdomen whitish grey with conspicuous dark brown pattern, consisting of a broad median vitta, dilated at apex, on fourth segment, and of a median basal spot connected obliquely with a pair of broad hind marginal spots on the second and third segments. Head with large dark brown spots on occiput and parafrontalia.....*nana*, Macq.
- 26 (23). Front tibiae with an *ad* and a *pv* seta, hind tibiae with a strong *ad* and *av*, without a *pd* seta. 6.5-7.5 mm. Four *post dc*, the anterior two pairs much weaker though very distinct, the posterior two pairs very strong and subequal. Abdomen grey dusted with a pair of large dark brown spots on segments 2-4, which leave only a narrow median vitta and the lateral anterior part grey-dusted. Head without conspicuous spots.....*neo*, Mall.
- 27 (20). Mid tibiae with an *ad* and a *pd* seta, front tibiae unarmed, hind tibiae with only an *ad* seta (*surda*?). Two strong *post dc* and sometimes a very small one in front of them. Palpi strongly dilated at apex. Abdomen grey dusted, with or without dorsal spots, with a row of elongate brown spots on lateral part of ventral surface. Apical ventral part of hind trochanters in male densely covered with short, spinulose, black setae.
- 28 (29). Abdomen with distinct brown paired spots on dorsum. Spinulose area of male hind trochanters smaller. (Typ. loc. Abyssinia).....*ambigua*, Stein
- 29 (28). Abdomen without dorsal spots. Spinulose area of male hind trochanters larger. (Typ. loc. Bloemfontein).....**ambigua surda*, Curr.
- 30 (19). Only one pair of *prst dc* (which are strong). *pv* seta of front tibiae present (*irvingi*?). Mid tibiae with only a *pd* seta, front tibiae without an *ad*, hind ones without a *pd* seta, but always with an *ad* and at least in female an *av* (*irvingi*?). Mid femora of male with a *pv* comb of dense black setulae at apex. Hind tibiae of male with a row of erect hairs in at least apical half of *pv* surface.

† Chaetotaxy of tibiae unknown, *dc* and size as in *pygmaea* but tibiae dark, except sometimes for their base (S. Abyssinia): **bipunctata*, Ség.

‡ Front tibiae not known, *dc* as in *nana*. Abdomen (and thorax) grey-dusted without pattern in male, third and sometimes second abdominal segments of female with a pair of brown longitudinal streaks. (Sokotra): **simonyi*, Beck.

- 31 (32). Tibiae strongly infuscated, base sometimes reddish. Abdomen glossy black with roundish dorso-lateral spots of white pollinosity on the second to fourth segments. Parafrontalia broadly shining black above. Male: the erect hairs of the hind tibia less than twice as long as the tibial diameter and present only on the *pv* surface. *prst dc* just behind middle of pre-sutural part of mesonotum.....*maculata*, Stein
- 32 (31). Tibiae reddish-yellow, at least the two posterior pairs and (*irvingi*?) the base of the front pair. Abdomen more largely grey dusted. Male: the erect hairs of the hind tibiae more than twice as long as the tibial diameter.
- 33 (34). Frontal triangle not nearly reaching anterior border of frons. Parafrontalia broadly shining black above. Abdomen with large black spots which are paired on the second and third segments, ventral surface cinereous-dusted except the posterior border of the fourth segment. Male: erect hairs of hind tibiae present on the apical two-thirds of the *av* and the apical three-quarters of the *pv* surface. Halteres reddish-yellow. (Typ. loc. Bloemfontein).....**irvingi*, Curr.
- 34 (33). Frontal triangle reaching anterior border of frons. Parafrontalia grey or brownish-grey dusted above. Abdomen of male with a very broad, black median vitta (sometimes narrowly divided by a grey dusted median line). of female with paired black spots.
- 35 (36). The *prst dc* at middle of presutural part of mesonotum, just beyond level of *ph*. 3.5–5 mm. Pollinosity of mesonotum grey between the brown vittae. Hind tibiae (♂♀) with 1–2 *av* setae (both much beyond the *ad*), those of male without erect hairs on the *av* surface, but with long erect hairs on apical half of *pv* surface. Abdomen of male with a broad median vitta which extends along hind margins of third and fourth segments and there meets a dark ventro-lateral vitta, the latter usually but not always present in female.....*leucospila*, Wied.†
- 36 (35). The *prst dc* at two-thirds of presutural part of mesonotum, closer to level of *prst* than to that of *ph*. 4.5–6 mm. Pollinosity of mesonotum cinereous between the brown vittae. Hind tibiae of female with an *av* seta, of male without *av* seta but with an *av* row of long erect hairs on apical half or more of *av* and *pv* surfaces. Abdomen of male often with a narrow median vitta of grey dust on second and third segments, otherwise as in *leucospila*, the ventro-lateral vitta absent in female.....*afra*, Curr.†
- 37 (18). *m* strongly curved forward at apex, especially in male. Halteres yellow. Hind tibiae with *pd*, *ad*, and *av* setae. 2+4 *dc*.
- 38 (43). Mid tibiae with only a *pd* or *pv* seta (or both, female of *barbipes*).
- 39 (40). Front tibiae without a *pv*. Male: mid femora with a row of strong *av* bristles in basal half, front femora very densely covered with fine, erect, black hair on more than basal half of ventral surface. Only the last two *dc* strong.....*nuba*, Wied.
- 40 (39). Front tibiae with a *pv* seta, which may be rather small in male but is conspicuous in female. Male: mid femora with the normal short appressed hairs near base of *av* surface and at most two long setae among them, ventral surface of front femora bare between the two rows of setae.

† Wiedemann's description does not indicate which of these two forms he had before him, but as Wiedemann's types came from India, and as all the Oriental specimens in the B. M. belong to *leucospila* in the above sense, hardly any doubt about its identification is possible. As the male *pectinipes*, Beck., has an *av* seta on the hind tibiae, according to Becker's description, this name can only be referred to *leucospila*. *L. afra*, Curr., was described from a female specimen only, which has the venter uniformly cinereous; it certainly is very closely related to *leucospila* and may either be the species identified above as *afra* or a synonym of *leucospila*.

- 41 (42). Male: mid tibiae with only a *pv*, mid femora with two strikingly strong, erect setae in basal half of ventral surface; hind tibiae with *ad*, *av* and *pd* and very long, setose hairs on the apical third (from the submedian setae to apex), hind metatarsus long, slightly curved, broadened in apical half, with fine, wavy hairs on *pv* surface, about thrice as long as tarsal diameter, and much longer and stronger wavy hairs on apical third of *av* surface. (Female with two setae on mid tibiae: *pv* and *pd*). Only the anterior two *post dc* somewhat weaker *barbipes*, Stein
- 42 (41). Male: mid femora without setae on ventral surface; hind metatarsus simple. Only the last two *dc* strong *modesta*, Stein
- 43 (38). Mid tibiae with an *av* (*sic!* at least in *cilitarsis*) and a *pd* submedian seta. Front tibiae with a *pv* seta. 2+4 *dc*, the anterior two *post dc* weak.
- 44 (45). Hind metatarsus of male long, slightly curved, with long curved ciliae on *av* surface, the longest of which are as long as the tarsal diameter, hind femora and tibiae curved, hind femora of male with a few long, erect setulose hairs in basal half, of female less curved, without any setae on ventral surface *cilitarsis*, Loew
- 45 (44). Hind metatarsus of male normal, without long ciliae, hind femora and tibiae not curved, hind femora of both sexes with a strong *av* seta at middle and another one (female?) near apex **longicollis*, Mg.
- 46 (3). Parafacialia with 1 (-3) strong setae at lower end (near the lower front end of the eyes), the strongest one not or hardly shorter than the strongest peristomatal bristles (*miochaeta*?). Halteres and palpi yellow, posterior tibiae and at least base of fore tibiae yellow. *m* almost straight at apex (sbg. *Chaetolispa*, Mall.)
- 47 (50). 1+2 *dc* which are strong. Grey-dusted pattern not very conspicuous.
- 48 (49). Mid tibiae with only a *pd* submedian seta, hind tibiae with only one (*ad*?) submedian seta. (Typ. loc. Kilimanjaro) **miochaeta*, Speis.
- 49 (48). Mid tibiae with an *ad* and a *pd* submedian seta, hind tibiae with a *pd*, *ad* and *av*. Front tibiae with a row of strong *ad* setulae which ends in a longer one somewhat beyond the *pv*; in male the *pv* developed as a long, fine hair, the *p* and *pv* surfaces with fine moderately long hairs in apical half *dichaeta*, Stein
- 50 (47). 2+3 *dc*, the first *prst* and *post* ones somewhat weaker, but very conspicuous. Thorax with three vittae, abdomen with large, sub-triangular, paired spots. Mid-tibiae with an *ad* and a *pd* submedian seta, hind tibiae with *pd*, *ad* and *av* *macfieii*, sp. n.

Lispe (*Chaetolispa*) *macfieii*, sp. n. ♀.

Length 6.0 mm., wings 5.3 mm.

Head one and a half times as wide as high, black, jowls and occiput grey dusted, temples, frontal triangle and upper part of parafrontalia cinereous dusted, face and lower part of parafrontalia golden dusted. Frons as wide in front as one eye (though appearing narrower), widest at the upper inclinate setae, where it is as wide as long, slightly narrowed to vertex, face strongly widened to lower margin of eyes, where it is more than one and a half times as wide as near base of antennae; parafrontalia one-fifth as wide as interfrontalia in middle, with two strong and three fine inclinate and two reclinate setae, the anterior of the latter much shorter than the posterior, with a row of setulose hairs along the eyes. Inner verticals strong, outer verticals rather strong, postverticals rather small, ocellars strong. Antennae fuscous brown, the apex of the second joint narrowly ferruginous, third joint more than thrice as

long as wide, its apex falling short of mouth-margin and exceeding lower margin of eyes by its width; arista long-plumose, the longest rays almost half as long as the third antennal joint. Palpi pale orange, only moderately spatulate. Parafacialia slightly widened below, somewhat wider than third antennal joint, with two irregular rows of setulose hairs, the lower extremity with a strong seta, jowls two and a half times as wide as third antennal joint.

Thorax black, cinereous dusted with three dark brown vittae, the median one being narrow and faint anteriorly, but moderately wide and dark brown behind up to the apex of scutellum (an indistinct and linear pair along the *dc*), and a conspicuous outer pair running through *ph* and *prst* and receding inward behind the suture, where it is dark and broad to the inward of *sa* and up to the *ia*. *acr* hair-like, in six irregular rows before suture; 2+3 *dc*, the first *prst* and *post* weaker though conspicuous; *ph* and the only *ia*, just before level of the last *dc*, not very strong, *prst*, *sa*, inner postalar and two pairs of scutellars very strong, notopleurals and outer postalar moderately strong; scutellum rather densely setulose on disc. Posterior propleural and upper prostigmatal strong, anterior propleural moderately strong, lower prostigmatal very fine, curved downward. *stpl* in a triangle, the anterior side of which is considerably shorter, posterior *stpl* very strong, anterior strong, lower one moderately strong.

Abdomen black, grey dusted, the outer surface more densely and more cinereous dusted, first to third segments each with a pair of large, subtriangular, dark brown spots on dorsum, the second to fourth, moreover, with a roundish spot at base of lateral surface, fourth segment with an inverted heart-shaped spot on dorsal surface. Each segment with a strong lateral discal, the fourth besides with two pairs of marginals, the other segments with the setulose hairs somewhat stronger towards sides of hind margin.

Legs: coxae, trochanters and femora piceous black, densely grey dusted, the apex of the femora light ferruginous, tibiae pale ferruginous, tarsi infusate, the last two joints fuscous. Front femora with four strong *pd* and about eight fine *pv* setae, front tibiae with a long and strong *pv* in middle; mid femora with one strong *ad* and *av* towards middle, two *pv* near base, and two *pd* near apex, mid tibiae with a *pd* seta at middle and an *ad* beyond middle; hind femora with ten rather strong though not very long *ad*, one strong *av* at basal third, a finer *av* before two-thirds, a strong *pv* at basal third, and a *pd* preapical, hind tibiae with a rather small *pd* seta at two-fifths, a strong *ad* slightly before and a rather strong *av* somewhat beyond middle.

Wings greyish hyaline with dark brown veins, which are paler at base. r_{4+5} and *m* slightly converging at apex, *m* a trifle upcurved; *r-m* at middle of discal cell, level with apex of r_1 . Calyptres whitish hyaline with pale yellow border and fringe, the lower one strongly projecting. Halteres pale ferruginous.

GOLD COAST: Accra, i.21 (J. W. Scott Macfie), ♀ type.

FANNIINAE.

The concept of this subfamily is rather labile with the various authors, as the typical genus *Fannia* is connected by such forms as *Euryomma*, the *Hydrolaea* group and *Ophyra* with the more typical PHAONINAE. None of the other Ethiopian genera of MUSCIDAE has the peculiar formation of the seventh vein, so distinctive of *Fannia*, in which the vein is bent round the apex of the short sixth vein in a sigmoid curve. In *Euryomma*, however, the sixth vein is similarly shortened, the seventh rather close to it and rather strongly curved, so that by further extension they would meet in a point, especially as the terminal part of the sixth vein is slightly curved toward the seventh. The position and direction of the two upper frontal setae is alike in *Euryomma* and the female sex of *Fannia*, and the row of orbital setulae which depends more or less on the parafacialia is also similar. Perhaps the most important

character, which has been overlooked so far, is the strictly dorsal position of the submedian seta of hind tibiae. This seta is in these two genera actually inserted between the two rows of setulae delimiting the dorsal surface, whereas in the Phaoninae, including *Hydrotaca* and *Ophyra*, it is inserted more or less to the inner (*p*) side of the inner (*p*) one of these rows, and is thus not in alignment with the *d* preapical seta. The *sc* is very similar in *Fannia*, *Euryomma*, *Hydrotaca* and *Ophyra*. All this tends to show that the FANNIINAE and PHAONIINAE are not very sharply separated.

Euryomma, Stein, which is distinguished from *Fannia* by the single *prst dc*, wholly pale legs, and, in the male sex, by the broad frons, is known from the most various parts of the world and regarded as a cosmopolite, but I have not so far seen any records from the Ethiopian region, nor are specimens available from that part of the world.

Key to the Ethiopian Species of Fannia. (Halteres always yellow.)

- 1 (8). Hind coxae without any setulae at apex of dorso-interior (*pd* in morphological sense) edge. Parafacialia setulose at and below middle, the setulae much smaller or absent between middle of parafacialia and anterior end of parafrontalia. Nowhere pale in ground-colour, except sometimes the base of the tibiae and the knees.
- 2 (7). Mesonotum, scutellum and legs thinly dark-brown dusted, almost entirely glossy brassy-black, except for the humeri and notopleurae, abdomen thinly greyish dusted on anterior lateral part of segments. Eyes conspicuously haired in male, distinctly short-haired or almost bare in female.
- 3 (4). *prsc* much behind level of last *dc*. Mesonotum glossy brassy-black up to hind margin. Eyes long-haired in male, shortly but very conspicuously haired in female. ♂: front tibiae without a tuft of setae at apex. ♂ 7, ♀ 6 mm.....*setigena*, Villen.
- 4 (3). *prsc* slightly before level of last *dc*. Posterior part of mesonotum, between *dc* and hind margin, pale grey dusted. Eyes with shorter hairs, in female often almost bare. ♂: front tibiae with a conspicuous tuft of scaliform setae at apex of posterior surface, which are at least as long as the tibial diameter.† ♂ 5-6, ♀ 4-5 mm.
- 5 (6). Hind trochanter (♂) slightly compressed on interior and posterior (morphologically, ventral) surface. Inferior forceps broadly truncate. *prsc* approximately half as distant from level of last *dc* as these from base of scutellum. (? n. syn. *F. babaulti*, Ség.).....*suturalis*, Stein
- 6 (5). Hind trochanter (♂) produced into a conspicuous though short, truncate process on interior-posterior surface. Inferior forceps strongly pointed. *prsc* approximately a third as distant or less from level of last *dc* as these from base of scutellum.....*fruticosa*, Stein
- 7 (2). Mesonotum, scutellum and abdomen largely and densely grey dusted, more or less dull, legs more distinctly grey dusted. Eyes bare. ♂ with a suffused brown transverse band behind suture, ♀ with brown dots at the base of the setae and hairs, particularly conspicuous in the anterior half of the *post* part of mesonotum. Abdomen whitish-grey dusted in male, dull grey in female, with a dark brown median vitta and, on the first three segments, an incomplete dark band along hind margin, which is narrower and more clearly defined in male. ♂ 3.5, ♀ 3 mm.....*fasciata*, Stein

† As in the palaearctic *manicata*, Mg., to which *fruticosa* and *suturalis* are very similar but not at all related, *manicata* possessing setae on the *pd* apex of hind coxae, bare eyes, *prsc* in normal position, the *v* pubescence of the mid-tibiae denser and longer near apex, etc.

- 8 (1). Hind coxae with 1-2 setulae at apex of dorso-interior (*pd*) edge. Parafacialia bare or setulose to at most middle, but then the setulae are of equal or decreasing size from the anterior end of the parafacialia to the lowest setula.
- 9 (10). Lower half of parafacialia linear, not quite as wide as base of arista, parafacial setulae descending to middle in both sexes, but minute. Abdomen nowhere pale in ground-colour, densely whitish dusted with a median vitta and paired spots in male, basal three segments dark brown dusted with pale grey dusted lateral anterior triangles in female, fourth pale grey dusted with a median vitta and a pair of small spots; sometimes the abdomen of the female with more extended pale pruinosity and thus more similar to that of male. 2.5-3.5 mm.....*leucosticta*, Meig.
- 10 (9). Lower half of parafacialia wider than base of arista, parafacialia bare in male, with some small setulae in upper half or less in female. *pv* setae of mid femora small and not very dense. Abdomen more slender, especially in male. 5-7 mm.
- 11 (12). Mesonotum with two brownish-black spots behind neck and a broad transverse band behind suture, scutellum brownish black on dorsum. Hind tibiae with two outstanding (and one small) *ad* setae. The basal three segments of abdomen largely testaceous, a median vitta and a hind marginal band dark*perpulchra*, Bezzi
- 12 (11). Mesonotum not with *Anthomyia*-pattern, usually grey dusted with incomplete, rather faint longitudinal vittae, sometimes more extensively brown dusted or even almost entirely brown (but not brownish-black) dusted, including scutellum.† Hind tibiae with a short row of *ad* setulae in male, of which only one is much stronger, seldom another one almost as strong as in *perpulchra*.
- 13 (14). Mesonotum with three brownish vittae or wholly dark. The basal three segments of abdomen usually more or less largely translucent yellow with a median vitta and a hind marginal band dark. Hind tibiae with 1-2 *av* setae. Hind coxae with two hairs at apex of dorso-interior edge. ♂ with the normal gradually and slightly curved setae on mid coxae, and with simple mid tibiae which are covered on ventral surface with short but dense, erect pubescence. ♀ with the setulae continued to about middle of parafacialia.....*canicularis*, L.
- 14 (13). Mesonotum with four or six incomplete brownish vittae, *i.e.*, without a median vitta. Base of abdomen not translucent yellow. Hind tibiae with 3-4 *av* setae. Hind coxae with one rather strong hair near apex of dorso-interior edge. ♂ with three strikingly strong setae among the normal ones on *av* surface of mid-coxae, their apices suddenly bent, the two exterior ones, opposite the apex of the trochanter, directed downward and forward, the interior one, opposite the base of the trochanter directed downward and backward; mid tibiae with a conspicuous hump on two-thirds of ventral surface. ♀ with the setulae continued to at most upper third of parafacialia.....*scalaris*, F.‡

† This is the case in a male specimen, identified as *canicularis* by Malloch: Natal: Ulundi, 5,000-6,500 ft., ix.1896 (*G. A. K. Marshall*); it has, besides, remarkably reddish legs, but is perhaps slightly teneral. There is a male of the European form of *canicularis* in the B. M., caught at Zanzibar, 26.ii.1921 (*W. C. C. Pakes*), but on board R.M.S. Carisbrook Castle, and several from S. Africa: Stellenbosch, 24-29.x.1925 (*R. I. Nel*). All these Ethiopian specimens have the characters of *canicularis*, L., as pointed out in Collin's recent key to the British species of the *canicularis* group (*Ent. Month. Mag.* **75**, 1939, p. 138).

‡ *F. scalaris*, F., has apparently not previously been recorded from the Ethiopian region, but the Imperial Institute of Entomology received from Prof. T. D. A. Cockerell a pair, collected by Mr. J. Ogilvie in the Cape Province: Graaf Reinet, 24-27.x.31.

COLLECTIONS RECEIVED.

The following collections were received by the Imperial Institute of Entomology between 1st April and 30th June, 1941 :—

AGRICULTURAL RESEARCH INSTITUTE, WAD MEDANI :—7 species of Aphidae ; from the Sudan.

Mr. H. E. BOX :—29 Lepidoptera ; from the Gold Coast.

Prof. P. A. BUXTON, London School of Tropical Medicine :—261 Diptera ; from Uganda.

Prof. G. D. H. CARPENTER, Oxford University Museum :—1,020 Curculionidae and 6 Hymenoptera ; from East Africa.

CORYNDON MEMORIAL MUSEUM, NAIROBI :—322 Coleoptera ; from East Africa.

Mr. J. L. FROGGATT, Government Entomologist :—18 Diptera, 174 Coleoptera, 147 Parasitic Hymenoptera, 27 other Hymenoptera, 64 Lepidoptera, 5 species of Coccidae, 26 other Rhynchota, 2 Planipennia, and 2 Ticks ; from New Guinea.

Mr. G. H. E. HOPKINS, Medical Entomologist :—26 *Glossina* and 2 slide preparations ; from Uganda.

IMPERIAL COLLEGE OF TROPICAL AGRICULTURE, TRINIDAD :—7 Ceratopogonidae.

Mr. R. A. LEVER, Government Entomologist :—9 Diptera, 13 Coleoptera, 6 Parasitic Hymenoptera, 13 Lepidoptera, 1 species of Coccidae, and 11 other Rhynchota ; from the Fiji Islands.

Mr. R. T. M. PEScott :—14 Diptera ; from Victoria, Australia.

Dr. ANNE R. SANDERSON :—4 Curculionidae ; from New South Wales.

Dr. V. G. L. VAN SOMEREN :—415 Coleoptera ; from Kenya Colony.

Mr. T. H. C. TAYLOR, Entomologist :—297 Lepidoptera, 12 Psocidae, 10 Planipennia, and 2 Ephemeridae ; from Uganda.

ON WATER-FINDING AND OVIPOSITION BY CAPTIVE MOSQUITOES.

By JOHN S. KENNEDY, M.Sc., Ph.D.

*Wellcome Entomological Field Laboratories, Wellcome Bureau of Scientific Research, London.***Introduction.**

In the past, workers on mosquito biology have, in words, recognized that the differences between the breeding-places of different species are probably due to the selection of her oviposition site by the female (Lamborn, 1922 ; Senior-White, 1926). They have, nevertheless, devoted the greater part of their energies to accumulating data on the intrinsic biological and physico-chemical features of the water of breeding-places. These features are on the face of it more likely to affect the larvae, and such work was therefore likely to lead, and did lead, to somewhat disappointing results.

In 1921, Herms & Freeborn published the result of a simple experiment pointing clearly to selection by the female, but which was not then followed up. They found no natural inter-mixing in the breeding-places of *Anopheles quadrimaculatus* and *A. punctipennis*, yet when they installed *quadrimaculatus* eggs in a *punctipennis* pool, both species developed equally well. Recently Bates (1940 a) and Thomson (1940) have shown by egg and larva surveys that where eggs occur, larvae of the same species and of all stages also occur. In these examples at least there was little "wastage" of eggs, that is, little determination of breeding-place by selection among the larvae. The position is still far from being cleared up. There is some evidence contradicting the above, and plenty of evidence that some selection does occur among the larvae. But enough is now known at any rate to cause us to shift the emphasis in these studies from the larva to the ovipositing female.

The work to be described was begun as the laboratory side of an investigation of oviposition and ovipository preferences, and concerns some of the simpler factors inducing oviposition in cage conditions, but it has not been possible to carry out the parallel field work.

Most oviposition studies, and they are not numerous, have been aimed at the discovery of preferences for water treated in different ways, while the process of oviposition and the stimuli concerned have been little studied. Until the recent appearance of Bates's paper (1940 a), even the manner in which *Anopheles* normally lays has been misunderstood. The behaviour of the raft-building *Culex* during actual laying is well known. Except that the eggs are dropped loose on the water the behaviour of *Anopheles* has been described as similar (Kerschbaumer, 1901 ; Herms & Freeborn, 1921 ; Leeson, 1931 ; Detinova, 1936 ; Kalandadze & Sagatelova, 1939). In the field Leeson (1931) has observed *A. funestus* sitting on the edge of a stone while laying, but Nuttall & Shipley (1901) and Bates (*l.c.*) found that in most cases Anopheline eggs in nature occur not in cohering groups but scattered. This, together with observations of dancing oviposition under semi-natural and cage conditions convinced Bates that (p. 510) "all of the species that we studied (in Albania) normally lay while performing an oviposition dance over the water."

As to the nature of ovipository responses to water, Detinova (*l.c.*) mentioned what appeared to be an important component, a habit of drinking some water before laying on it, and failure to lay when the proboscis was withdrawn quickly. Kalandadze & Sagatelova (*l.c.*) could not confirm this, and the present work has also given no support to the idea of such "water-testing" as a regular practice. Lamborn (1922) suggested that olfactory responses played a large part, but this was not based on any findings. Otherwise, even suggestions are generally lacking.

Material and Methods.

The three "laboratory" mosquitoes, *Anopheles labranchiae atroparvus* (to adopt the terminology for the members of the *A. maculipennis* complex proposed by Bates, 1940 b), *Aedes aegypti* and *Culex pipiens molestus* were the subjects of this study. The *Anopheles* strain has been bred in this laboratory since 1938, when eggs were obtained from Mr. Shute's stock derived from near Rochester, Kent, in 1933. The *Aedes* came direct from Tanganyika in 1934, and the *Culex* from Elberfeld, North Germany, in 1932.

The study of ovipository behaviour presents several difficulties inherent in the nature of that behaviour itself. All three of these mosquitoes lay most readily in very little light, both in the sense of choosing a darker place when given a choice and in the sense of doing most of their laying during the darkest part of the night. Secondly, mosquitoes about to lay are very easily distracted by obstacles or disturbances. Conditions cannot all be arranged with the aim of displaying a suspected reaction to a given stimulus, for here the aim is rather to determine the existence and rôle of reactions in a definite behaviour process, oviposition. Thirdly, the readiness even of gravid mosquitoes in suitable conditions to lay at any desired time can by no means be relied on. In practice, the *Culex* were used for experiments after a minimum period of nine days from emergence and *Anopheles* and *Aedes* after a minimum of four days from feeding, but actual oviposition by all of a given batch of females on the same night was a rare occurrence. A series of tests on the percentage of females out of a batch laying at different periods from emergence or feeding gave very inconsistent results. With *Culex*, for example, given water for the first time nine days after emergence, an average of 54 per cent. laid on the first night (40 trials), but the percentage varied from 0 to 100.

Direct observation of the mosquitoes soon showed, however, that as a prelude to oviposition they behave in certain recognizable ways, to be described below. With this ready means of ascertaining whether the experimental mosquitoes were showing ovipository responses, the method of direct observation was extensively used. Where it could not be used results were based as far as possible on eggs laid in dishes provided.

Where neither of these methods was applicable, reliance was placed on the fact, also revealed by direct observation, that mosquitoes with eggs carry out a great deal of pre-ovipository movements without actually completing the performance by laying. In effect, it appeared that such mosquitoes either remain quiescent, or their activity takes the form of pre-ovipository behaviour, whether or not it is consummated on the occasion or night in question, and provided always that they are left to themselves, free of extraneous stimuli. That being so, it was possible to set traps for the mosquitoes overnight with reasonable assurance that those caught would have been engaged on pre-ovipository behaviour. *Culex* was principally used in these experiments, as its autogeny ensured a more plentiful supply for this purpose than of the forms needing blood for their eggs, and *Culex* lays readily in drier air than does *Anopheles*. It should be noted that according to Jobling (1935) the autogenous females are less discriminating in their light preferences than the blood-fed females.

Before oviposition could be expected it was necessary to provide conditions conducive to spontaneous activity. This was done by reversing the normal daily light cycle in a darkened laboratory and providing a long period of bright light, from 4.30 p.m., to 10.30 a.m. On a day when observation was intended the bright light was often left on for another hour or so in the morning for *Anopheles* and *Culex*, with the apparent effect of intensifying the activity thus "pent-up," when the light was finally turned off. During the "dark" period any change of illumination from dark to dim or *vice versa* acted as a stimulus to greater activity, so that several short observations between periods of complete darkness proved better than

one long one. Under these conditions, and at a temperature of about 26 C. and relative humidity of 60-80 per cent., ovipository behaviour was frequently induced under observation.

The cage used for the direct observations was 40 cm. square and 28 cm. high. The walls were white cotton on three sides, which proved essential in order to see the mosquitoes in flight. The observer looked through the fourth side, which had glass outside and white mosquito netting inside. The roof was white cotton, with four layers of blue and green tissue paper above. The dim light bulb (40 watt) was fixed 50 cm. above the roof, and a cover confined the light from this to the interior of the cage. The floor was of plywood and reversible, one side white and the other black, with a 10 cm. diameter hole in the centre (the "target") to hold a dish of water or the other materials tried.

Further particulars of methods are described under the appropriate sections.

Normal Cage Behaviour.

These observations were all made in the cage already described, using a white floor with a dish of rain-water in the centre, also with a white background. As will be seen, more ready laying would have been obtained with a black background to the dish, but this made observation more difficult.

Anopheles.

Under the above conditions females of *Anopheles* were watched laying over 20 times, apart from the previous observations on *labranchiae labranchiae* in Tirana (Bates, 1940), and will be described as a standard with which *Culex* and *Aedes* may be compared.

Throughout these observations and particularly at the beginning of an observation period, the mosquitoes spent a good deal of time flying to and against the roof of the cage. This seemed to be the only extraneous reaction intervening. After a few minutes, however, the mosquitoes began to make descents to the floor. Often this was an ordinary diagonal flight movement, but sometimes the descent was virtually a "pancake." Arrived at the floor they flew about at rates varying between 25 and 50 cm./sec. (mean of 10 readings, 36 cm./sec.), and at a height which might reach 7 but was more usually 2-4 cm. In the course of this flight they dipped again and again to touch the floor, at intervals varying between 6 and 20 cm. (mean 13 cm.). There was little hesitation in the flight, but the directions followed appeared to bear no relation to the dish, being completely random. The mosquitoes seldom remained longer than 2-3 seconds on the floor, flying up to the walls or roof after one or two traverses. This type of flight may be termed "skim-hopping."

With the dish of water in place, skim-hopping mosquitoes could not help but cross it sooner or later. When they did so without touching the water they seldom showed any response, and even those mosquitoes which did touch did not invariably respond. But a mosquito that touched the water in flying over it usually changed its mode of flight abruptly. It began to hover, with little displacement in space. Sometimes it kept in almost exactly the same spot, or bobbed up and down 1 cm. or so vertically or obliquely, or again, it swang through an arc 2-10 cm. wide, dipping at each end. The female usually dipped to touch the water surface at intervals which might rarely be as long as a minute. Contact with the water was made with the second and third pairs of legs. Even while hovering several centimetres above the water surface, the accuracy with which the female kept within the margins of the dish was striking.

This may be termed the "hovering" phase of ovipository behaviour, and it was during it that actual oviposition occurred. Once a mosquito was in this phase it was much less easily disturbed by, say, a bright light or mechanically than in the other phases, as if it were in a trance.

Hovering almost invariably preceded and accompanied laying, but a great deal of hovering was observed without laying. Some laying usually took place during actual hovering, but under these cage conditions more eggs were laid after the female had come to rest on or at the edge of the water. A female would frequently execute bouts of hovering, with or without laying, interspersed with intervals of sitting or walking on the water, again with or without laying. In fact a female seldom completed its laying without one or more excursions away from the dish altogether.

These observations do not support Bates's suggestion that the hovering without laying and the general changeability of behaviour in this phase are abnormal, at least in cage conditions. In the one observation of *Anopheles* laying in the field (Leeson, 1931), the mosquito also showed "nervousness" and shifted from one place to another in the middle of laying a batch of eggs. On the other hand there is good evidence for Bates's view that the tendency to lay while at rest, so that the eggs form a close batch, increases as the size of the container decreases, and that the normal field method of *Anopheles* oviposition is to scatter the eggs while hovering. The changeability of cage behaviour in this phase may be in part due to the confined space and especially the small area of water available.

Mosquitoes which had made contact with the water and passed off the dish over the floor again, showed yet a third type of flight. This was not so clear-cut or uniform as "skim-hopping" or "hovering," but was usually distinguishable from either, being intermediate between them. Hovering properly might continue for a few moments over the floor and eggs might be dropped there. Very soon, however, with or without making contact with the floor, the mosquito lapsed into what may be termed "hover-skimming." It moved from place to place less rapidly than in "skim-hopping" and more hesitantly, hovering loosely and drifting at the same time, with frequent changes of direction and dips to touch the floor. In general, the behaviour was more erratic than in other phases, speed of locomotion, height and contact frequency varying much. Bouts of hover-skimming lasted 3-10 times as long as bouts of skim-hopping. When a hover-skimming mosquito crossed the water again it usually resumed hovering immediately and often without touching the water first. Nevertheless, here again the flights round the floor were quite random in direction.

Culex.

In *Culex* (17 observations) the skim-hopping phase, before water was encountered, was very like that in *Anopheles*, except that the movement was slower (8-30 cm./sec.) and less straightforward. Dips to touch the floor were slightly more frequent, the spacing varying between 6 and 20 cm. The second phase was quite different. The response to contact with the water took the form of immediately coming to rest upon it. With open water as in these observations there was never any suggestion of hovering. On the water there was sometimes a certain amount of walking about, but the greater part of the time was spent sitting still, and the eggs were laid thus sitting as has often been described. The third, "hover-skimming," phase was again very like that of *Anopheles*. The flight here was steadier, and in this respect more like the skim-hopping phase than in *Anopheles*. A mosquito encountering the water for the second time after a bout of hover-skimming always touched the water before sitting and laying, again unlike *Anopheles*. Eggs were never laid, either flying or sitting, on the dry floor.

Aedes.

The behaviour of *Aedes* (15 observations) prior to the first encounter with water differed markedly from that of *Anopheles* and *Culex*, in that clear and repeated descents to the floor did not occur. There was a discernible tendency to fly around near the floor, but it was slight, the mosquitoes flying about the cage at all levels. The first phase consisted therefore of little more than random activity. As in *Culex*, the response to contact with water was to come to rest upon it, but *Aedes* seldom

stopped "dead" as *Culex* did, spending much time walking, hopping, flitting or almost hovering from place to place, as well as sitting inside or just outside the rim of the dish. There was never any sustained or steady hovering as in *Anopheles*, and contacts with the water or floor were very frequent. Laying itself was always executed sitting. *Aedes* will lay on an open water surface, but as is well known, it prefers to lay at or just above the water edge, particularly where there is a rough surface. *Aedes* reaction in the second phase was thus to stop flying and walk or flit about until a suitable edge was found, and the fidgeting involved here was probably prolonged owing to the smooth edges of the dish used.

The third, "hover-skimming", phase was more normal. As in the others, a "hovering" mosquito often left the dish altogether, continuing very similar behaviour while moving round the floor. Movement was slower than in *Anopheles* or *Culex*, and less sharply distinguished from behaviour over water in the second phase. There was the same slow almost hovering drift from point to point of contact as was sometimes seen over water, although the mosquitoes did move about more and did not often settle. Like *Culex*, *Aedes* never resumed full "hovering" (second phase behaviour) on the dish without contact with the water.

In all three mosquitoes, therefore, the only evidence of a directed reaction (taxis) contributing to water-finding, even in so small a space, was the repeated descents to the floor made by *Anopheles* and *Culex*. On the floor the mosquitoes' movements seemed quite random. On encountering the water they responded both by reducing the rate of locomotion (or stopping it entirely) and by changing direction more often, that is, by ortho- and kline-kinesis reactions respectively*. For all three it appeared that actual contact with water might be the main operative stimulus under these conditions. *Anopheles* was least dependent on contact, especially on returning to the dish after a previous encounter with it.

Stimuli operating at the Water.

The bulk of the data under this head was provided by direct observation. The same observation cage was used, but in place of water in an open dish with a white background and a white surrounding floor, the "target" was occupied by other materials so as to separate different factors, and a black surrounding floor was also used. The arrangements can be divided into four main groups: I, white floor, unscreened target; II, white floor, screened target; III, black floor, unscreened target; and IV, black floor, screened target. The screen was made of black cotton mosquito-netting stretched on a wire ring lying over the target hole. Since white netting interferes with the view of any surface below it, black netting was used even when the surrounding floor was white. Within each of the above groups the target was varied in the following ways:—

- | | |
|---------------------------------|---|
| 1. White paper alone. | 4a. Black velvet paper under glass. |
| 2. White paper under glass. | 5. Mirror. |
| 3. Black paper alone. | 6. White paper under dish of water. |
| 3a. Black "velvet" paper alone. | 7. Black paper under dish of water. |
| 4. Black paper under glass. | 7a. Black velvet paper under dish of water. |

3a, 4a and 7a were used only in groups III and IV. 1, 6, the condition in the observations on "normal" laying, is included here for comparative purposes.

In addition, some observations were made with the floor entirely composed of white netting, with a light background below (Group V). Tests were made here

* "Ortho-kinesis: speed or frequency of locomotion dependent on intensity of stimulation. Kline-kinesis: frequency or amount of turning per unit time dependent on intensity of stimulation" (Fraenkel & Gunn, 1940).

with: (1) nothing, (2) a dish of liquid paraffin, and (3) a dish of water under the netting, all with the same light background.

The results of these observations were recorded in the form of notes on behaviour, but for summarizing it was necessary to put the responses shown into categories and grade them in each category on an arbitrary numerical scale, as follows:—

- A. *Attraction* (also termed "visits"). Directed reaction (taxis) to the target in the course of otherwise random flights. Graded according to frequency and clarity.....0-3
- B. *Flying ortho- and klino-kinesis, positive to target*. The rate of locomotion and/or rate of change of direction increases over target; ranging from mere hesitation in flight (1), to full hovering response (*Anopheles*) or immediate settling on water (*Culex*) or settling with small movements (*Aedes*) (4). With surfaces other than water, however, *Culex* and *Aedes* behave more like *Anopheles*, even hovering to some extent, although never so firmly.....0-4
- C. "*Touch-downs*." Dips made by flying mosquitoes to touch the target, ranging from a single one made by an attracted mosquito (1), through one or two extra ones made by a skim-hopping mosquito while crossing the target (2) to touch-downs made so frequently and with such close application as to constitute a rapid "bouncing" on the target0-4
- D. "*Grounded*" ortho- and klino-kinesis positive to target. Virtually an extension of category B, but including walking, sitting (often at edge) and probing on the target surface. Graded according to frequency and duration.....0-4
- E and E'. *Klino-kinesis negative to target*. Avoidance of target in favour of surrounding floor. Ranging from mere absence of any crossing of the target by skim-hopping mosquitoes without clear reactions, to clear avoiding reactions at the target edge. When the target combines both "attractive" and repellent features the avoiding reactions are provoked more frequently, and may occur in the same exposure as B or D type responses occur. Category E includes only those cases where there were either no B or D responses, or where these were shown by different mosquitoes or by the same mosquitoes at different times. Category E' includes those cases where mosquitoes showed B or D and E responses simultaneously, that is, showed the B or D responses only at or just off the edge of the target without passing out over the centre of the target surface, "keeping their distance" as it were.....0-3

Actual laying is not included among the categories of responses, as the exposures were not generally long enough to allow the mosquitoes to reach that stage.

The figures obtained in this way for a given species in a given set of conditions were then averaged. The whole series of data is summarized in Table I and figs. 1 and 2, from which evidence of the operation of particular factors may be extracted.

Contact.

The importance of actual contact with the water was suggested already by the observations on "normal" laying. Table I and figs. 1 and 2 show, however, that even when water is absent or screened ovipository responses can be evoked to a considerable extent. When water was present but screened, the responses were of a different type (more C and D, less B), but hardly less vigorous than when it was unscreened. In the absence of water, good pre-ovipository responses were obtained; for instance, on glass over black paper (target 4). While contact with water was thus not essential for these responses, the completion of the ovipository act involves contact as an important factor, as the following experiments showed.

TABLE I.

Summarized results of direct observations on pre-ovipository behaviour.

Group	Target	Mosquito	No. Exposures	Grades of reactions in behaviour categories						Group	Target	Mosquito	No. Exposures	Grades of reactions in behaviour categories										
				A	B	C	D	E	E'					A	B	C	D	E	E'					
I	1	Ano	6	0	0	0	0	0	0	III	1	Ano	4	0	0	0	0	2.7	0					
		Cul	12	0	0	0	0	0	0				Cul	5	0	0.2	0	0	2.8	0				
		Aed	4	0	0	0	0	0	0															
	2	Ano	14	0	0	0	0	0.2	0			2	Ano	10	0	0.2	0.2	0	0.9	0				
		Cul	10	0	0.8	0.4	0	0.1	0					Cul	10	0	0.9	0	0.3	1.8	1			
		Aed	5	0	0	0	0	0	0															
	3	Ano	6	2.6	1.4	2.0	0	0	0			3a	Ano	8	1.0	0.3	0.5	0.1	0	0				
		Cul	7	3.0	0.9	1.3	0.6	0	0					Cul	4	1.0	1.5	1.5	1.0	0	0			
		Aed	5	2.5	1.3	1.8	1.3	0	0															
	4	Ano	6	2.7	3.0	3.7	2.0	0	0			4	Ano	9	0	0.2	0	0	0.3	0				
		Cul	9	2.8	3.0	2.9	2.7	0	0					Cul	7	0	2.6	2.7	0.9	1.4	1			
		Aed	5	3.0	3.0	3.0	3.0	0	0															
	5	Ano	6	0.2	0.5	0.3	0	0	0			5	Ano	9	0	0.3	0.3	0	0.9	0				
		Cul	7	0.6	2.6	2.3	1.1	0	0					Cul	9	0	2.0	1.7	1.0	0.7	0			
		Aed	6	0.3	3.0	3.0	2.7	0	0															
6	Ano	9	0	2.3	1.6	1.4	0	0.2		6	Ano	3	0	3.0	1.0	0	2.0	0						
	Cul	5	0	1.0	1.3	2.5	0	0				7	Ano	3	0	3.0	1.0	3.0	0	0				
	Aed	5	0	3.0	3.0	3.0	0	0			IV	1	Ano	3	0	0	0	0	1.5	0				
7	Ano	5	3.0	4.0	1.5	2.0	0	0					Cul	5	0	0	0	0	0.8	0				
	Cul	4	3.0	1.0	2.0	4.0	0	0		2			Ano	3	0	0	0	0	1.0	0				
	II	1	Ano	6	0.8	0	0.3	0	0	0		3	Ano	2	0	0	0	0	0	0				
Cul			4	1.0	0.3	0	0	0	0				Cul	2	0	0	0	0	0	0				
2		Ano	3	1.0	0.3	0.7	0	0	0			3a	Ano	2	1.0	0	0	1.0	0	0				
		Cul	5	1.0	0	0.4	0	0	0					4	Ano	2	0	0	0	0	0	0		
3		Ano	6	2.3	1.5	2.0	0.3	0	0					Cul	3	0	2.0	1.7	0	0.3	0			
		Cul	4	2.8	1.8	1.8	0.3	0	0							4a	Ano	1	0	2.0	1.0	2.0	0	0
4		Ano	6	3.0	3.0	2.2	1.2	0	0			5	Ano	3	0	0	0	0	0.5	0				
		Cul	5	3.0	3.4	3.5	1.0	0	0						Cul	4	0.3	2.5	2.5	0	0	0		
5		Ano	4	0.8	2.0	1.8	0.3	0.8	0			6	Ano	7	0	0.7	0.8	0	0.9	0				
		Cul	3	1.3	2.3	2.3	0	0	0						Cul	3	0	2.5	2.0	2.5	2.0	2		
6	Ano	4	0	2.5	2.5	2.0	0	0		7	Ano	5	0	1.8	2.0	0.4	0	0						
	Cul	3	1.0	2.7	2.7	2.7	0	0					Cul	2	0	3.0	3.0	3.0	0	0				
7	Ano	3	3.0	4.0	4.0	4.0	0	0		7a	Ano	4	0.5	3.2	3.2	3.0	0	0						
	Cul	3	3.0	4.0	4.0	4.0	0	0																

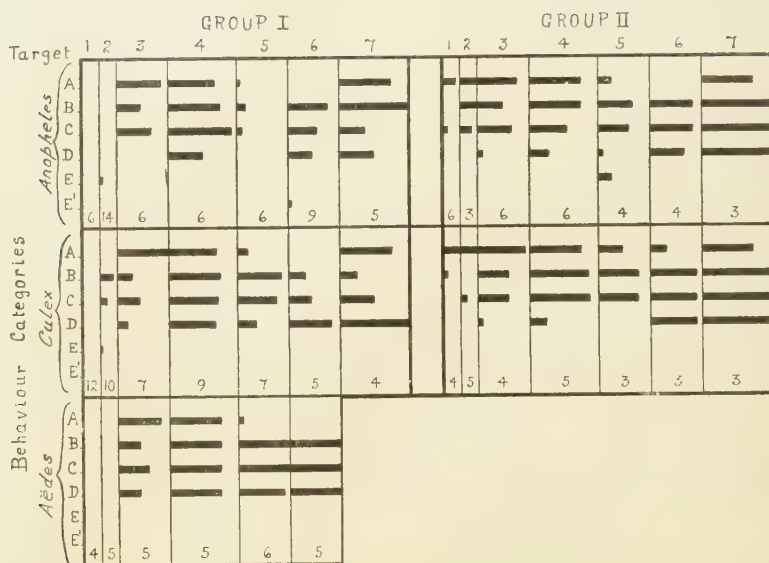


Fig. 1. Results of direct observations on pre-ovipository behaviour in Groups I and II. Data from Table I. Figures in each space are numbers of exposures of each target.

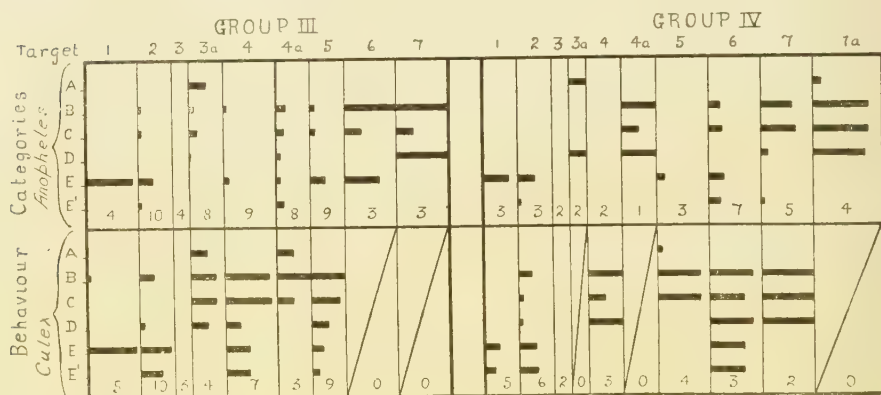


Fig. 2. Results of direct observations on pre-ovipository behaviour in Groups III and IV. Data from Table I.

Both *Culex* and *Aedes* refused consistently to lay at all on any dry surface. For them access to water is indispensable for oviposition. *Anopheles*, on the other hand, did lay a proportion of eggs on a screened dish of water put in the ordinary breeding cage alongside an open water dish. In these experiments (Table II) a disc of black paper or cloth was laid in the bottom of the dishes, as it was known that more laying could be obtained in this way. The results suggest that contact with water is not essential for oviposition in *Anopheles*, but, as *Anopheles* lays while hovering, it is possible that contact was made with the water in the open dish and subsequent laying was inaccurate, some eggs falling on the screened dish and some perhaps on the dry floor.

TABLE II.

Laying by Anopheles on screened and open water offered side by side.

	Nights	Total	Percent. layings in dishes	
			open	screened
<i>labranchiae</i> *	12	116 (batches)	73	27
<i>atroparvus</i>	6	12,265 (eggs)	75	25

* Experiments on *labranchiae* and *superpictus* were carried out with the support and under the auspices of the International Health Division of the Rockefeller Foundation, at the Tirana Malaria Research Laboratory.

To clear up this point two identical dishes, one containing water and the other dry (no screens) were put in the cage together one night, the water dish alone the next night, the dry dish the next night, and so on (Table III).

TABLE III.

Laying by Anopheles on dry and water dishes, offered side by side and singly.

	Nights	Dish	Batches in dishes		
			water and dry	water alone	dry alone
<i>labranchiae</i>	9	water	82	81	—
		dry	5	—	0
<i>superpictus</i>	15	water	78	72	—
		dry	1	—	0

Eggs were not laid on the dry surface when there was no open water available, but some eggs were "spilled over" on to the dry surface when there was water present to initiate the ovipository responses. Laying on black paper surrounding a dish of water has occurred repeatedly in our experience. It is understood that the absence of water here refers to its absence on a given night, but its availability on an adjacent night. *Anopheles* deprived of water for some days after they are ready to lay will deposit eggs on a dry black or even white surface, especially in a moist atmosphere.

In the next experiment with a screened dish, this and the control open dish were each put in alone on alternate nights. During eight nights *labranchiae* laid 99 batches of eggs on the open water and six on the screened dish. Thus contact is clearly very important for full ovipository responses in *Anopheles*, although water is still able to induce some laying when it cannot be touched. The optical effects of a screen over water were controlled in this last experiment by having the dishes in the cage only during the completely dark period. In the other experiments this was not so, but the great bulk of laying is done during the hours of darkness. At the same time netting can be an optical as well as a mechanical obstacle to laying, as the weaker B, C and D responses to black paper under glass, when this was screened, indicate (Table I and figs. 1 and 2, II. 4 against I. 4).

To sum up, contact with water is important for the completion of the ovipository act in all three mosquitoes. It is not indispensable for *Anopheles*, but is for *Culex* and *Aedes*. For all three, other factors are more important in the earlier phases of oviposition.

Air Humidity.

Although laying on untouchable water is inhibited, all three mosquitoes showed vigorous responses to it, which took the form of a modified hovering with numerous "touch-downs" and some crawling and probing on the screen. The duration and intensity of these responses varied considerably, being at their greatest with black paper under the dish under the black screen, with a white surrounding floor (II. 7). The responses were evoked by the water vapour emanating from the dish, as Table I and figs. 1 and 2 show. If any target including a dish of water under the screen (II. and IV., 6 and 7) is compared with arrangements without water (II. and IV., 1-5), the former induces better responses than the latter. Appearance is controlled inasmuch as II. 2 and 6, II. 4 and 7, IV. 2 and 6 and IV. 4 and 7 are mutually identical in this respect. Moreover, in Group V, where the entire floor being of white netting reduced the visibility of anything below, no responses were evoked either with nothing or a dish of paraffin under the floor, except perhaps a slight avoidance of the paraffin by *Anopheles* (probably due to light reflection, see below). A dish of water, appearing exactly like paraffin, produced good responses.

Thus the water vapour emanating from a water surface plays an important part in evoking pre-ovipository responses in mosquitoes coming close to the surface. The strength of the reactions varies according to other factors, which must therefore also play a part.

Brightness and Conspicuity.

Such optical stimuli are of course not confined in their operation to the immediate vicinity of the water surface. Throughout the direct observations it was apparent that the frequency and clarity of flights straight to the target, mainly seen in mosquitoes starting from higher levels in the cage ("visits," category A), depended on how dark, or rather how contrastingly dark, the target appeared. The placing of the black netting screen over the target in itself provoked such visits, when they had been little, if at all, evident before (compare I. 1, 2, 5 and 6 with II. 1, 2, 5 and 6). With a white floor, black paper alone induced visits to an extent comparable with those induced by any other arrangement of the target. The acuity of the mosquitoes in this respect is emphasized by the fact that while they naturally made no visits to a target of plain black paper when the surrounding floor was also black, they did visit a target of black "velvet" paper with the same plain black floor (III. 3 against 3a). On the other hand the attracting stimulus was not the mere inconspicuity of the target, irrespective of whether it was darker or lighter than the surrounding floor, as a white target surrounded by a black floor was definitely avoided and not visited (III. and IV. 1, 2 and 6), as was the mirror (III. and IV. 5) which was the most conspicuous from above as it directly reflected all the light it received from the ceiling.

Aside from these "visits," further reference to which will be made below (p. 291), the brightness or darkness, and the conspicuity, also influenced the ortho- and klinokinetic responses which kept the mosquito over the target once it had arrived there. In groups I and II, where the surrounding floor was white, better B, C and D responses were always obtained with the darker of two otherwise similar targets (1 and 3, 2 and 4, 6 and 7). In groups III and IV, with a black floor, black velvet in the target proved more effective than plain black (3 and 3a, 4 and 4a, 7 and 7a), other conditions being equal. The black surrounding floor in groups III and IV distracted the mosquitoes from the target, making their reactions there less persistent than in groups I and II. This applied even in the cases where a dish of water was present (6, 7 and 7a).

Thus mere conspicuity does not attract or stimulate ovipository responses in the mosquitoes, nor does the relatively brighter appearance that water, owing to reflection from its surface, has against a plain background. A dark appearance does on the other hand attract and stimulate the mosquitoes, the most effective target in this respect being one that is conspicuously dark against its surroundings.

Reflection.

When the factors so far considered are allowed for, there still remains a body of data in Table I which require a further factor to account for them. It was shown that a lighter target is, in respect of its brightness, less stimulating than a dark one. On that ground targets including a sheet of glass, which reflects some light, should be less stimulating than those that absorb it all. Yet glass over black paper (4) induced better responses than black paper alone (3) in all four groups, as was the case with black velvet paper in groups III and IV. Even with white paper (1), by itself not stimulating at all, the addition of a sheet of glass (2) induced weak responses in some cases. Similarly the mirror induced responses as good as or better than black paper alone in groups I and II (white floor) in spite of the brightness of the former, and in groups III and IV (black floor) the mirror was not only better than the neutral black paper target, but also than white paper under glass, very similar as regards brightness. The better responses with glass over black paper compared with black paper alone were not due to the different textures of the two surfaces, as the responses differed in the same way when both surfaces were out of reach under a screen.

Thus, while mere brightness of the target against its surroundings induces no responses and is repellent, the presence of a reflecting surface induces ovipository behaviour whether the target is lighter or darker than its surroundings (within limits). The conclusion must be that the factor of reflection is itself a stimulus.

In two experiments with *Culex*, laying was compared on a dish of open water (white background) and on a soaking pad of white lint. This experiment was first done under normal room lighting, when 426 rafts were laid during 24 nights, and of these 66 per cent. were laid on the open dish. The same comparison done in complete darkness for seven nights gave 182 rafts, of which equal numbers were laid on the lint and on the water. The discrimination between the smooth and the interrupted water surface was therefore optical rather than tactile, and in this case, since both dishes were white, the optical stimulus must have been reflection.

Reflection from smooth surfaces such as water or glass has not been mentioned in the literature as playing any part in mosquito behaviour, nor, to my knowledge, in connection with the behaviour of other animals. Certain aquatic beetles (*Dinutes*, Weiss, 1914), when removed from their pond, fly directly back to it, having first risen to a height which increases as the distance from the pond increases. This strongly suggests an optical stimulus, but neither here nor in the few other similar cases has the investigation been carried any further.

The manner in which the reflecting powers of a smooth surface act as a stimulus is not clear. It may be suggested that the reaction is a case of a "compensation" reaction. That is, the movements of an animal in the vicinity of a reflecting surface result in the images reflected from the surface appearing themselves to move in relation to the rest of the optical field. Effective "compensation" of this apparent movement involves facing and going straight to the surface. However, such directed movements from a distance to the target were not noticed, except where the latter also presented a contrastingly dark appearance which is itself attractive. As the source of illumination was above, the mirror, viewed from one side, and so reflecting only the walls, appeared somewhat darker than the white floor, so that "visits" recorded here (I. 5) may have been due to that. The reactions to reflecting surfaces were rather seen in mosquitoes already arrived directly over the target, where these reactions, ortho- and kline-kinetic, prevented the mosquitoes from passing off again. The mechanism of this is harder to conceive, but may perhaps be regarded as compensation of the apparent movement of background images in relation to the mosquito's own image, which of course necessarily remains stationary in relation to the mosquito itself.

Table I and figs. 1 and 2 further show certain differences between the three species, especially in the relative importance of the light and reflection factors. With the white floor and no screen (I) *Anopheles* gave good responses to black paper and to black paper under glass, but distinctly poor ones to the mirror, unlike *Culex* and *Aedes*. With the floor black and the target screened or unscreened (III and IV) reactions of *Anopheles* to the mirror were, again, comparatively weaker than those of *Culex*. It appeared that the light responses of *Anopheles* were stronger, in relation to the reflection responses, than was the case with *Culex* and *Aedes*. The brightness of the mirror prevented *Anopheles* from reacting as well to it as to black paper under glass, and a black floor distracted them from the target. *Anopheles* reacted well to the mirror only when it was under the black screen with a white surrounding floor (II, 5), and there was some avoidance shown even here.

While *Culex* was more responsive to reflection than *Anopheles*, irrespective of the brightness conditions, it showed a greater dependence on the darkness of the target than did *Aedes*. *Aedes* reacted on arrival about equally well to black paper alone, black paper under glass, the mirror, and water with a white background, although in the last two cases it was not initially attracted to the target. Any one of the factors which had a greater or lesser stimulating effect on *Anopheles* or *Culex* seemed able to provoke vigorous responses in *Aedes*, which is, in other words, less discriminating.

Stimuli operating from a small Distance.

The direct observations suggested that in the cage conditions obtaining the mosquitoes found the water largely by random movements, except when the dish presented a contrastingly dark appearance against the rest of the floor, and except inasmuch as *Anopheles* and *Culex* made descents to the floor before making the random movements. It might be expected that the humidity gradients around the dish would also assist in directing the mosquitoes to the water. These three points were studied in further experiments.

Air Humidity.

The forms of the humidity gradients and convection currents set up round a dish of water in still, unenclosed air are virtually unknown, and their study would be a considerable task in itself. The first experiments indicated, however, that for present purposes it was not essential.

The apparatus was set up on a table in the middle of a room, where the somewhat crude method of observing a cigarette smoke trail showed that there were no draughts. The cage was made entirely of cotton mosquito netting on a wire frame, being 60 cm. long, 20 wide and 12 high. The mosquitoes could not be allowed to touch the water, so the results could not be based on layings, and an effective means of trapping the mosquitoes was required. The usual type of mosquito trap on the lobster-pot (tapering entry) principle proved impracticable when built on such a small scale, no doubt because the internal surface area is relatively so small as to make too easy the finding of the entry hole again. The ease with which water-seeking females are distracted by any obstacles made it impossible to increase the efficacy of such traps by reducing the size of the entry. They were used in the tests on vertical movements (see p. 295) because they were effective during the few moments when the mosquitoes were disturbed in counting, to prevent the mosquitoes escaping from a region where they had collected but had had neither time nor stimulus to leave. Dishes or plates with a low rim containing a layer of liquid paraffin 1-2 mm. deep, on the other hand, proved entirely satisfactory, at least for recording preferences shown in the course of movements along the floor. "Skim-hopping" mosquitoes encounter such traps and are able to fly freely up to the moment of being caught.

Two such paraffin traps (6 by 16 cm.) were put inside the cage, one against each end wall. Two 10 cm. petri dishes were placed side by side outside each end, one

pair containing distilled water, and the other containing liquid paraffin as a control of appearance. The water and paraffin dishes were interchanged after each day's count of the mosquitoes caught. *Culex* was used for these experiments, and in one pair of experiments the water and paraffin dishes were laid on the table level with the cage floor to test for any attraction from the side, and in another pair the dishes were put underneath the end portions of the cage floor to test for any attraction from above (Table IV).

TABLE IV.

Trapping tests with Culex in the vicinity of water.

Water dish position	Nights	Total trapped	Average percentage trapped at water end	Difference from 50 per cent.
Level with cage floor				
(a) against wall	12	304	59.7	9.7 ± 4.0
(b) 10 cm. from wall	8	181	54.0	4.0 ± 3.7
Under cage floor				
(a) 1 cm. below floor	12	196	71.5	21.5 ± 3.2
(b) 11 cm. below floor	8	115	52.0	2.0 ± 21.7
Control: paraffin dishes both ends...	8	154	51.5	1.5

While the available area of water surface was admittedly small, the conclusion is that in more or less still air the mosquitoes are not attracted to water, either from above or from the side, from more than 10 cm. away.

Although the air in the room was dry enough (50–70 per cent. relative humidity) to create a gradient as steep as, if not steeper than, those likely to be encountered in nature, the conclusion reached may not be so surprising when it is remembered that still air must seldom exist in nature. There the water vapour emanating from a body of water would not take the form of a series of gradients radiating out in all directions, but of a more gentle gradient in only one direction, according to the direction of local air movement. The joint effects of activation by a moist air current and orientation of flight along that current, comparable to the mechanism of up-wind host-finding investigated in *Aedes aegypti* (Kennedy, 1940), very probably play an important part in water-finding in the field.

Light.

The preference many ovipositing mosquitoes show for water with a dark background or shaded is well known (Buxton, 1927; Jobling, 1935; Bates, 1940; Thomson, 1940). That this involves real attraction, that is a directed reaction, over at least 20 cm. was evident in the direct observations (p. 288). The shade or dark background preference can clearly be of great importance in the field, but for present purposes the point, which has been less well appreciated, is that the preference for a shady place can only be exercised by actual visits to more and to less shady ones. On the other hand an attraction to a dark-looking place would operate from a distance and thus constitute a more efficient preference mechanism; even where mosquitoes show a preference for water with a dark-coloured background but entirely unshaded, it cannot be assumed that this reaction takes place at a distance, rather

than after the female has arrived over the water. The following experiment was designed to separate these two components.

The mosquitoes were released in a cage 98 by 28 by 44 cm. high, facing a window and containing three jars, the positions of which were interchanged daily. Each jar was 10 cm. in diameter and 9 cm. high, and carried a lid 18 cm. square supported 2.5 cm. above the rim. The jars contained distilled water 3 cm. deep, and their outsides and lids were covered with paper. The control jar had a single layer of white tissue paper and four vertical strips of opaque white paper one-eighth the circumference of the jar in width and equally spaced, and an opaque white lid. Thus it appeared uniformly white from outside and was moderately well lit inside through the tissue paper interspaces. The "shade" jar and lid were also papered so as to appear uniformly white from outside, but under the tissue paper round the jar was another layer of black paper, so that inside the light was very dim. The interior of the "contrast" jar received exactly as much light as the control jar, through white tissue paper interspaces, but the four vertical strips were black outside, as was the upper surface of the lid. Thus any preference for the shade over the control jar could only be shown by mosquitoes after passing under the lid into the interior of the jar, that is by some kinetic reaction. Any preference for the contrast over the control jar could only be shown by mosquitoes still well outside the jar, that is by some "tactic" reaction.

TABLE V.

Laying in jars designed to resolve preferences into their directed and kinetic components.
("s" indicates a statistically significant difference.)

	Nights	Total layings	Percentage layings in jars		
			control	shade	contrast
<i>Anopheles</i>	9	145	26.5	31.7	41.8
			s		
<i>Culex</i>	12	295	22.3	39.7	38.0
			s		
			s		
<i>Aedes</i>	9	101	23.5	39.2	37.3
			s		
			s		

Table V shows the results in terms of the percentages of all layings in the three jars. In the case of *Culex* both layings and percentages refer to rafts, but in the case of *Anopheles* and *Aedes* where the separate layings are hard to distinguish, the percentages are calculated on the actual total numbers of eggs (9,086 *Anopheles* and 3,558 *Aedes*), while the figures for layings were estimated from previous experience that a laboratory laying by *Anopheles* includes about 70 eggs and *Aedes* about 35.

All three mosquitoes showed a preference for a more shady and a more contrastingly appearing jar. The two test jars were about equally favoured by *Culex* and *Aedes*. *Anopheles*, however, showed a stronger preference for the contrasting jar than for the

shady one, although the standard error of the difference between the two percentages is slightly more than half the difference itself. The preference of *Anopheles* for the shady jar over the control is weaker than that of *Culex* and *Aedes*, the difference between the percentage layings being quite insignificant statistically, whereas in *Culex* and *Aedes* the difference is over twice the size of its standard error. It appears that the more efficient "tactic" component plays a larger part with *Anopheles*.

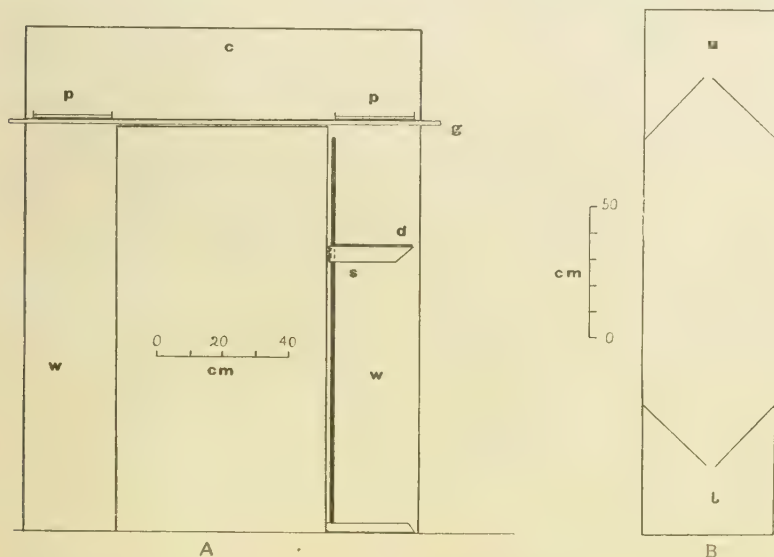


Fig. 3. A. Diagram of apparatus for determining limiting distance for attraction of *Culex* to a dark object: *c*, paper-walled cage; *pp*, paraffin traps; *g*, glass floor of cage; *ww*, paper-walled "wells" under each end of cage, containing *s* stand carrying *d* disc of black paper. B. Diagram of cage for trapping *Culex* in course of vertical movements: *u*, upper and *l*, lower traps.

A further experiment was carried out with *Culex*, to determine the limiting distance over which it could be attracted to a contrastingly dark object. For this a paper-walled cage with a glass floor was used, 60 by 20 by 14 cm. high (fig. 3). Under each end portion of the cage there was a paper-sided well 20 by 14 cm. in section and 62 cm. deep, in which a 10 cm. disc of black velvet paper could be set at any desired height. A paraffin trap was placed inside the cage on the floor at each end, and the black disc set in each well on alternate nights. This arrangement with the attracting disc in a well under the floor was deemed necessary in order to ensure that the range of movement of the mosquitoes, in making their choice of the two ends of the cage, would not appreciably affect the apparent size of (angle subtended by) the black disc; and also, that the variation in the distance away of the black disc (variation of angle subtended) would not alter the effective range of movement needed to make the choice. These conditions would not have been satisfied either if the disc had been displayed through the end wall of the cage, or if it had been below but unenclosed and hence visible from any point along the cage.

The size of the black disc is given in Table VI in terms of the angle it subtended from the surface of the cage floor directly above it. When this angle was reduced to between 10 and 5 the mosquitoes ceased to be trapped in a majority at the disc

end of the cage. They could thus be attracted to a piece of dark-looking open water two metres across from 11 metres directly above it, or from $3\frac{1}{2}$ metres to the side of it at a height of 2 metres.

TABLE VI.

Trapping of Culex over a black disc of varying apparent size.

Angle subtended by black disc	Nights	Total trapped	Percentage trapped over disc
160	8	128	74
53	6	187	64
26	10	370	60
13	10	575	60
9	14	792	53
5	8	757	50

TABLE VII.

Laying in water dishes, one on and one raised above the floor.

	Nights	Total laid	Percentage laid in floor dish
<i>Anopheles</i> (batches)	8	114	96
<i>Culex</i> (rafts) ...	12	212	87
<i>Aedes</i> (eggs) ...	12	2,307	47

Gravity.

In the first tests to obtain numerical confirmation of the pre-ovipository descents to the floor and of the consequent approach to the water along the floor, the results were based on actual layings. In one set two dishes were used, one on the cage floor and one raised 8 cm. above the floor on a wire frame. The differences between *Aedes* and the others (Table VII) are suggestive, but the results with the others might be explained if the mosquitoes were assumed to fly "feeling" against all the walls, not merely along the floor, and hence to lay in the floor dish simply because this was the only "wall" where there was a dish. In the next set of experiments (Table VIII), therefore, three dishes were arranged on shelves one above the other inside a light-tight cage 1 m. high and 25 cm. square, the dishes being equidistant from each other and the roof and floor, so that no dish could be favoured on account of its proximity to a "wall." The preference for the bottom dish was still clearly shown. Another test with three dishes raised on stands and equidistant from the roof and floor in the breeding cage of *Anopheles* gave similar results: 21 top, 15 middle and 64 per cent. in the bottom dish (total of 5,248 eggs, nine nights).

TABLE VIII.
Layerings in three water dishes in a vertical row.

	Nights	Total laid	Percentage laid in dish positions		
			high	middle	low
<i>Anopheles</i> (batches)	8	69	12	26	62
<i>Culex</i> (rafts) ...	8	166	13	10	77
<i>Aedes</i> (eggs) ...	10	2,253	21	35	34

The strong preference for the lowest dish shown by *Anopheles* and *Culex*, but not by *Aedes*, is in conformity with the results from direct observation. However, the direct observations also showed that laying in the lowest of a series of dishes need not represent the results of a reaction carried out *before* water was encountered. An encounter with water induces hovering and hover-skimming, both of which involve closer application to the floor and more frequent "touch-downs" than prior to the encounter. Thus even if an upper dish were encountered first the response would be to drop lower so that laying would probably take place in the dish closest to the floor. In order to prove the pre-ovipository descent, tests were necessary without any water in the cage.

This required the use of traps. It was found that paraffin plates raised off the floor failed to catch sufficient mosquitoes, so that the shelves were removed from the light-tight cage and sheets of glass fitted to make two traps, one 25 cm. from the top and the other 25 cm. from the bottom. Each trap consisted of two sheets at right angles with a 9 mm. slot between their inner edges, the upper trap leading upwards and the lower downwards (fig. 3). These traps were not entirely effective, as when the cage was opened to the light in the morning the mosquitoes could be seen escaping one by one from the lowest to the upper compartments of the cage, but the traps did prevent the mosquitoes from altering their distribution during the brief period required for counting. The mosquitoes were put in the centre compartment of the cage in the afternoon during their inactive period, the cage closed down, and the number in each of the three compartments counted next morning. 204 *Culex* were used in the course of eight nights, and of these 10 per cent. were found in the top compartment, 21 per cent. in the middle and 69 per cent. in the bottom. This is clear evidence of an overnight downward shift, even in the absence of water.

Although light differences were controlled here, there were always slight temperature and humidity differences, the top being 0.2-0.8 C. warmer and 1-4 per cent. drier than the bottom. To control these factors a smaller cage (35 cm. high) was used, on the same plan with two-way traps, but which fitted in a sealed glass jar in a dark incubator. A little water was put in the bottom of the jar out of reach of the mosquitoes, and the jar closed down and left in the incubator for 24 hours before the mosquitoes were inserted in the middle compartment. There was still a temperature gradient in the cage, but reversed, the bottom being 0.2-0.5 C. warmer than the top. Owing to this gradient and to slight temperature fluctuations in time, the air in the jar was not uniformly saturated and reliable measurement of the humidity gradients proved impracticable, but it may be assumed that this gradient too was reversed as compared with the conditions in the unsealed cage.

This apparatus was used to test the overnight vertical shifts not only of gravid, but also of hungry and of freshly engorged females (Table IX). The persistence of the downward shift in the gravid females shows that we are concerned here with a reaction to gravity, positive geotaxis. It is interesting that the hungry females behaved in the same way, while the engorged one did so only to a slight extent, remaining, as was to be expected, in a majority in the middle compartment where they were put.

TABLE IX.

Trapping of Culex to show vertical movements.

	Nights	Total caught	Percent. distribution		
			top trap	centre space	bottom trap
Gravid	9	145	18	22	60
Hungry	7	182	15	30	55
Fed ...	6	157	10	55	35

If such descents to the ground take place overnight, it suggests that there must be a cycle of vertical movements made by the mosquitoes in conjunction with their activity cycle, and so dependent on the diurnal light cycle. To investigate this, the stocks of *Culex* were kept from emergence in the reversed light cycle, so that their active period occurred during the day, when periodic records were made of their distribution in a vertical cage without traps or water. The cage was made of white cotton and triangular in section to provide a clear view from one slightly truncated corner of all the interior walls. It was 1 m. high with sides 25 cm. long. The cut-off corner, 2 cm. wide, was covered with mosquito netting, and could be screened with a flap of material between readings.

40-50 *Culex* females were introduced the evening before (bright lights on) and readings were started before the bright lights went off in the morning and continued until the dark period was passed and the bright lights had been on for an hour or so in the evening. This was done with a simple cycle of 19 hours bright light and 5 hours darkness, and the light fixed alongside the centre level of the cage; with a cycle of 18 hours bright, half an hour dim, four hours dark and another half-hour dim before the bright again, both bright and dim lights being set above the cage; and finally with the same cycle of bright, dim and dark periods, but both lights set at the centre level. Readings were taken on seven days with the first cycle, seven with the second and three with the third.

The counts of mosquito distribution could not always be accurate, as the mosquitoes were sometimes moving, and during the dark period it was necessary to use the hand torch for the minimum possible time. The figures for the four sections of the cage were therefore reduced to percentages. In order to obtain a single set of figures expressing the shift in distribution from each reading to the next the following method was used. Given a top-to-bottom percentage distribution at one reading of 56-12-8-24, which became 36-7-17-40 at the next reading, the two sets are put down one above the other. Note is made of the additions and subtractions between the figures in the first set needed in order to change it to the second. The figure for each percentage transferred from one section to another is then multiplied by the number of section boundaries traversed in so doing, and the products are summed. The final total is a measure of the over-all shift in distribution, upwards or downwards, as in this example:—

	<i>Top</i>		<i>Bottom</i>		<i>Shift</i>
First reading	56	12	8	24	<i>products</i>
		—5	5	5 × 1	5
	—4		4	4 × 2	8
	—16			16 × 3	48
					—
Second reading	36	7	17	40	Total shift 61 DOWN ("D.61")

TABLE X.

Vertical distribution shifts by Culex during the diurnal cycle.

(Bright light on 6.30-1.30, dim light on (Series 2 and 3 only) 1.30-2.00 and 6.00-6.30.)

Lighting	Series 1		Series 2		Series 3	
	Period	Shift	Period	Shift	Period	Shift
Bright	0-1.20	U.8	0-1.20	D.4	0-1.20	D.4
Dim	—	—	-1.35	D.9	-1.35	D.26
	—	—	-1.55	U.39	-1.55	U.29
Dark... ..	-1.40	D.29	—	—	—	—
	-2.10	D.50	-2.10	D.90	-2.10	D.64
	-2.30	D.9	-2.30	D.23	-2.30	U.10
	-3.00	U.21	-3.00	U.16	-3.00	D.37
	-4.30	D.36	-4.30	D.5	-4.30	U.18
	-5.35	D.2	-5.35	D.1	-5.35	U.7
	-6.25	D.6	—	—	—	—
Dim	—	—	-6.05	U.43	-6.05	U.33
	—	—	-6.25	D.50	-6.25	D.13
Bright	-6.35	U.58	-6.35	D.20	—	—
	-7.00	D.50	-7.00	D.24	-7.00	D.46
	-24.00	U.30	-24.00	U.88	-24.00	U.62

The results in each series of experiments with given lighting conditions are averaged in Table X, and these figures are plotted in fig. 4. It should be emphasized that the data are only represented in fig. 4 by the points, each of which is placed above or below the preceding point by an amount proportional to the observed shift in distribution since the preceding reading. The lines joining the points often distort the facts: for instance, in Series 2 and 3 the ascent recorded at 6.05 hours did not begin at 5.35 hours, but only after the dim lights came on at 6.00.

Clearly there is a diurnal cycle of vertical movements, even when the illumination is evenly distributed between the top and the bottom of the cage. Previous experiments indicated that the movements here are not connected with the slight vertical temperature and humidity gradients, but are geotactic. Alongside the distribution readings a rough record was kept of the degree of activity displayed by the mosquitoes, and when these are considered together a close and presumably causal relation is found. In Series I there was very little activity in the bright light period, of course, and when the light went out there was no sudden jump in activity, but a steady, fairly rapid increase during which the mosquitoes made their main shift toward the cage floor. The mosquitoes remained at the bottom, but activity then declined and the few active individuals tended to ascend. During the last two hours of darkness activity attained a moderate level, with a generally downward trend. The incidence of the bright light evoked, in the now "awakened" mosquitoes, a great burst of activity in the form of a general ascent, but as activity again declined to a more "normal" level downward movements again predominated. During the long period of very slight activity in the bright light movements were generally upward.

Similarly, in Series 2 and 3, the small descent when the light changed from bright to dim was associated with a growing but not yet excessive amount of activity, which soon became very great and changed into a general ascent. In the dark, activity became more normal and the first main descent took place. While activity continued moderate, there was little change in distribution, most of the mosquitoes remaining near the cage bottom. Subsequent changes were also associated with activity changes, the ascent when the dim light came on accompanying a great burst of flying, with a subsequent decline to "normality" and a descent, until the slow ascent of the inactive period set in.

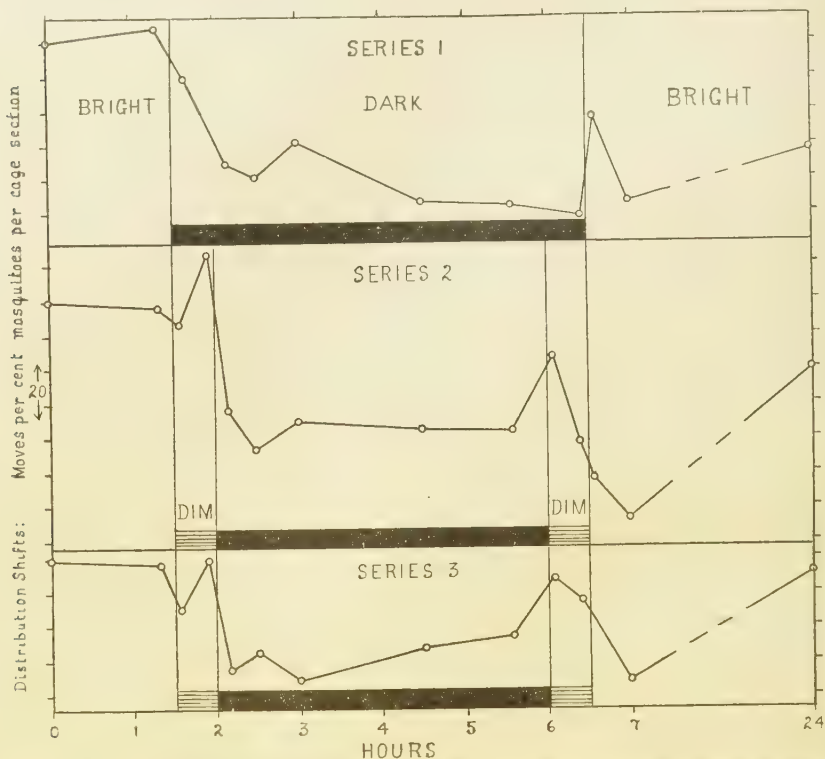


Fig. 4. Graph showing vertical distribution shifts made by *Culex* during the diurnal cycle. Data from Table X.

The largest shifts, both upwards and downwards, took place in Series 2, where the lights were set above the cage. General activity was not appreciably greater in this series, so that the movements must be considered to have been reinforced by light responses. It is a familiar fact that highly excited mosquitoes tend to make "escape" movements towards a source of light, and to behave variably in dimmer light and a "normal" state of excitation, being sometimes attracted to a light and sometimes to darkness; but these reactions require fuller investigation. Neither here nor in Hundertmark's (1938) apparatus was provision made for the separation of photo-tactic from photo-kinetic responses. In any case Hundertmark, while demonstrating a reversal from negative to positive between day and dusk reactions, did not employ gravid females. Thomson (1940) found that *Anopheles minimus*

was definitely photo-negative when seeking an oviposition site, with which these results accord.

We may conclude that *Culex* shows a reversal of geotactic response according to the activity level, which in turn depends on the diurnal light cycle. In the inactive and the highly excited phases it is negatively geotactic, while in the phase of "normal," "spontaneous" activity it is positive. In nature these responses would be reinforced by light reactions.

The approach to the water along the ground was confirmed in *Culex pipiens pipiens* in the laboratory garden, where egg-rafts were found in a small pond on the lawn. Two glass paraffin traps were placed on the ground at the water edge on opposite sides of the pond, two similar traps raised 45 cm. above the first two, and a fifth 45 cm. above the centre of the pond. In the course of seven days the raised centre trap caught one, the two raised side traps two, and the ground traps 124 gravid females. A pair of traps, one on the ground and the other raised 45 cm., were placed 14 metres from the pond, where the raised trap caught two and the ground trap 60 gravid females, in 21 days.

Conclusions.

Taken alone, this work might lead to the conclusion that water-finding is largely a matter of random movements, and that the three species differ little in the responses which lead them to oviposit. However, a dish of distilled water in a cage is of course an immeasurably simpler arrangement than any body of water in the field. An experienced observer can recognize a breeding-place as likely to harbour certain species, and he does so on the basis of many components, often hard to define, which make up the "landscape" of the breeding-place.

Another important feature of cage work is that the effects of previous reactions concerned with feeding, resting, etc., are left out of account, whereas in the field they can exercise an indirect effect on the choice of breeding-place. Thus, in the laboratory garden *Culex pipiens pipiens* was found to favour certain tubs for laying when these were very similar to others in water composition, exposure, etc., apparently because of their proximity to dense weeds where the mosquitoes rested.

On these two grounds alone the process of water-finding in the field could not be expected to be as random as was the case in cages. Nevertheless it is striking that for all three mosquitoes there was such a large random element. Both the water vapour and the reflection from the water only act when the mosquito has already arrived. A contrastingly dark appearance was the only feature shown to be able to attract the mosquito directly from a small distance. Is it then generally the case that water does appear darker than its surroundings in dim light in nature? Very often, obviously not, but it is probably true to say that the breeding-places of these mosquitoes do appear dark.

Inasmuch as *Culex* and *Aedes* breed in well-shaded and even completely covered-in water, the entrance to the water will appear contrastingly dark. The more exposed waters utilised by *Anopheles* and to some extent also by *Culex* may appear lighter than their surroundings from above, owing to reflection from the sky. However, it has been shown here that mosquitoes descend to the ground and come upon water in the course of flights along the ground. Given any vegetation or other dark-appearing objects near or surrounding it, water does appear darker than its surroundings from near the ground. Once the mosquitoes, attracted from along the ground to such dark-appearing water, arrive over it, the coming into view of the reflection of the lighter sky will not repel them, as their other responses, to reflection itself, to humidity and to contact, will come into play and allow them time to find the shadier parts of the water surface.

Factors intrinsic to water (suspended or bottom matter) which affect how dark it appears, necessarily affect also how well it reflects, since the more light reflected from suspended or bottom material the less clear the images reflected from the surface. Plant or other floating matter must similarly, in interfering with surface reflection, influence oviposition responses, as was shown on p. 289. Such effects of intrinsic factors on the external appearance of water provide a possible link, apart from the often mentioned one of odour, or Detinova's (1936) "taste," between water composition, flora and fauna, and the responses of ovipositing mosquitoes.

Very few of the properties of breeding-places are dealt with here, but the findings are at least consistent with the known differences between the breeding-places of the three species. This work would lead to the expectation that *Anopheles labranchiae atroparvus* would use breeding-places more contrastingly dark than *Culex pipiens molestus* or *Aedes aegypti*, and on the ground, which accords with their breeding in open-air pools and ditches. *Aedes* would be very elastic, able to use any water in or near its habitat, above as well as on the ground, contrasting or not, preferring only that the water be shady, which accords with their domestic habitat and catholic breeding habits. *Culex* would occupy an intermediate position, more catholic than *Anopheles*, but using ground water more than *Aedes*, and on the ground, less contrastingly dark (more open) water than *Anopheles*. The breeding-places of *Culex pipiens molestus* are comparatively little known. They appear to resemble those of *C. p. pipiens* with regard to exposure and appearance (although not in degree of pollution), and the findings here accord with the ability of *pipiens* to breed both in domestic receptacles, such as tanks and water butts, and in cesspits and open pools.

Summary.

1. The behaviour of *Anopheles labranchiae atroparvus*, *Culex pipiens molestus* and *Aedes aegypti* has been studied before and during oviposition.
2. *Anopheles* and *Culex* when ready to lay make repeated descents to the ground and fly about with a skimming-hopping movement, while *Aedes* flies about generally, at all heights.
3. On encountering water *Anopheles* breaks into a hovering flight, laying its eggs during this "oviposition dance" or while settled on the water. *Culex* stops "dead" on the water and lays its eggs settled there, as does *Aedes* but with some fidgeting about. After encountering water mosquitoes may leave it again, but fly about the floor more steadily and persistently than before.
4. Among the factors which stimulate mosquitoes after they have arrived directly over a water surface, contact with the surface is essential for actual oviposition by *Culex* and *Aedes*, and almost so for *Anopheles*. Good pre-ovipository responses may be induced by water vapour alone and by the reflection from the surface, although how this latter stimulus acts is not clear. A dark appearance, especially if the surroundings are relatively light, facilitates these responses.
5. Direct attraction of the mosquitoes over the short range available in a cage was only induced by a contrastingly dark appearance, but *Anopheles* and *Culex* are aided in water finding by diurnal changes, correlated with light and activity changes, in the sense of their geotactic response.

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NOTES ON *GLOSSINA LONGIPENNIS* AND ITS BREEDING-PLACES.

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(PLATES IV & V.)

Glossina longipennis is a species of tsetse-fly of which very little is known beyond its general distribution. In Kenya Colony, it inhabits extensive areas of the sparsely populated districts in the north and east. It extends across the coastal hinterland and penetrates into Tanganyika, where it is found in the Pare-Usumbara belt (Potts, 1937). The species also occurs in a somewhat isolated belt in the vicinity of the lower Southern Uaso Nyiro in the Masai Reserve and continues into the Sonjo-Natron fly-belt of Tanganyika Territory.

This fly has not up to the present affected agricultural development in Kenya; neither has it been incriminated in serious outbreaks of trypanosomiasis, although it has been associated with isolated cases of the disease in animals. In fact it usually infests only the dry and unproductive areas of the Colony.

Within the last eight years or so, it has been realised that provision will have to be made for the expansion of native agriculture and for additional settlement in the alienated areas. The presence of tsetse on the border of some of the alienated land and in unoccupied native country threatens to prevent future development; and *G. longipennis* in a number of localities will play an important part in limiting expansion.

The Carter Land Commission (1933) recommended the addition of 512 square miles to the Ukamba Reserve "for the relief of congestion in the years to come." This area, locally known as Makueni, in the Machakos district, had been reported by a senior Administrative Officer as low-lying and fly-infested but of great fertility. A preliminary fly survey of parts of Makueni showed that *G. pallidipes* and *G. brevipalpis* infested the river-courses and patches of thicket between the valleys. A few *G. longipennis* were taken away from the rivers, but it was impossible then to ascertain whether this species had established itself as the other two had done, because the adults were so few and scattered. Nothing was known of the breeding-places, since the puparium had never been discovered. Similar difficulties were encountered with *G. longipennis* in another investigation on a newly occupied European farm near Emali station on the Mombasa-Nairobi railway. On this latter occasion, it was decided to pay a visit to the Voi-Makindu fly-belt in order to obtain some data on the fly and to determine the kind of habitats in which it lived and bred.

The Voi-Makindu Fly-belt.

The northern section of this fly-belt, from near Kiboko station to Makindu, is infested with *G. longipennis* and *G. pallidipes* and to a less degree with *G. brevipalpis*. The belt as a whole stretches from the Tana River area, across the railway and the main road, and continues from Voi, Kibwezi and Masongaleni, along the Tsavo River to near Lake Jipe. It includes parts of the Chyulu range of hills, passes near the Kiboko Rivers and curves north-easterly to the Ithumbwa hill east of Simba. Thereafter, it stretches back to the Athi River, and covers most of the Makueni area already mentioned.

The country from Kiboko to Makindu may be described as *Commiphora-Acacia* savanna, the dominant *Commiphora* spp. being interspersed with *Acacia mellifera*

and patches of *A. drepanolobium*, *A. seyal*, occasional *Balanites aegyptiaca* and baobab, and scattered *A. pennata*.

The *Commiphora* spp. are in rather close formation (Plate IV, fig. 1) in the wide, undulating areas between rivers, with here and there a few thickets of small dimensions. Open grassland occurs in the wooded savanna, and comprises chiefly the grasses *Cenchrus ciliaris*, *Chloris myriostachya*, and *Pennisetum masaicum*. Nearer the river-beds, *Themeda triandra*, *Hyparrhenia filipendula* and *Cynodon plectostachyum*, are the prevalent species.

The area examined appeared to be of a locally moist type adjoining a drier country. A number of river-beds, which contain water in the rainy season only, run roughly from west to east. The lesser Kiboko, however, is a permanently flowing stream. These riverine courses are heavily wooded and fringed with thickets. *Acacia campylacantha* towers above other large trees and dense bush consisting mainly of *A. pennata*, *A. mellifera*, *Cordia ovalis*, *Grewia* spp. and *Acalypha fruticosa*.

North of the greater Kiboko, which is a seasonal river, the country changes into a vast plain with a few clusters of bush on some of the scattered hills, in the depressions and around watering-places. South of the last occupied farm at Emali, there is a wide long strip of practically treeless, flat land, which appears to be an effective barrier to the unaided dispersal of tsetse.

Observations in the fly-belt were made from the 21st to 23rd March 1941, a few weeks before the onset of the long rains; and although they may not entirely be applicable to other fly-belts inhabited by *G. longipennis*, the results enable fly surveys to be carried out with greater confidence and efficiency.

Only two adult *G. longipennis* were collected during the hours of bright daylight on the four days spent in the infested area. More were observed on the wing, and captured, early in the mornings. By far the largest numbers were taken late in the evenings.

The patrols, provided with screens and hand-nets, travelled through the savanna, along the river-beds, railway and road, but failed to find any species other than *G. pallidipes* until sunset. One team of fly-boys moving up-stream did not meet with *G. longipennis* before arriving at a bridge over the lesser Kiboko. On reaching the road at about 6.20 p.m., *G. longipennis* seemed to dart out of the bush through which the boys had just passed. Following the road for approximately 200 yards from the bridge, as many as 32 flies were caught in 20 to 25 minutes. The darkness made further catching impossible. It was noted that the flies became suddenly active when the sun was disappearing over the horizon. Only one or two flew on to the screen, a few appeared behind the patrol. The majority dashed across, and to the front of the team, alighted on the road a yard or so before and facing the approaching patrol, as if waiting for an opportunity to attack. In this situation they were caught by a swift sweep of the hand-nets. In the short time from dusk to darkness, the flies were very numerous and appeared eager to feed. Even when they could no longer be seen, they were heard all round the party of fly-boys. The experience was identical for three nights, and although a second team patrolled the road for hours prior to dusk, it was not until a few minutes before sunset that the flies became active.

Attempts to obtain more specimens by using powerful torches and hurricane lamps in conjunction with screens were unsuccessful. A team of boys was put in the back of an open lorry driven along the road and through the savanna, but no flies were caught. A few, however, did enter the cab of the lorry, and were captured. Lighted lamps and torches were exposed in the bush, and at the mouth of the tent well inside the infested zone. *G. longipennis* did not seem to be attracted to the stationary lights.

All the specimens caught were males ; and it may be of interest to note that large numbers were collected within 200 yards of the flowing Kiboko River. Others were captured over a stretch of 2,000 yards of road between this river and the greater Kiboko, which contained no water. Two flies were caught at night in the dry savanna about five miles below the lesser Kiboko. Not a single specimen was obtained in the thickets : yet it seemed that most of the flies came out of this type of bush.

At the conclusion of this short investigation, three of the fly-boys were instructed to travel by train from Emali station, about 18 miles from the fly-belt, to Nairobi. The train left Emali at approximately 4.30 a.m. The boys, unaware of the attraction of trains for *G. longipennis*, reported that when they had entered the train they noticed no less than 20 flies in the carriage in which they were accommodated. They collected 8 specimens, but were unable to get the remainder partly because of the many passengers, and partly because the flies escaped among the masses of luggage. They reported further that on arriving at Sultan Hamud, many of the natives with their luggage left the train ; and no *G. longipennis* were seen in the carriage afterwards.

This information suggested a means by which this species of tsetse reached the European-occupied farm already referred to, which extends from near Emali to Sultan Hamud. It has long been known that *G. longipennis* enters trains travelling at night through the Voi-Makindu fly-belt. Specimens have been taken in the neighbourhood of Nairobi and in the town itself. Isolated flies have been collected on other farms situated near the railway line, and cases of animal trypanosomiasis have been diagnosed. Lorries and cars, especially those passing at night through, and beyond, the Voi-Makindu fly-belt probably serve to carry *G. longipennis* to localities outside the infested areas.

Neave (1912) stated of *G. longipennis* : " it appears to be absent from the sea-coast, where the climate is probably too humid for it. It would seem to be independent of water, and indeed rather to avoid it. I found it most striking, when travelling from station to station on the railway between Voi and Makindu, to find numbers of this species in the dry, semi-desert, thorn-bush country between rivers, while on the river banks it was replaced by *G. brevipalpis*. Like the other large species of *Glossina*, it is chiefly on the wing and inclined to feed in the early morning and late evening." Chalmers & King (1913) reported that the localities in which *G. longipennis* had been found were either desert or semi-desert. In elevated regions, it occurred between rivers, and not on their banks. Anderson (1921) collected specimens on the moist swampy flats near to, and on the banks of, the Southern Uaso Nyiro in the Masai Reserve ; and Potts (1937) found the fly inhabiting moist country typical of *G. brevipalpis*, and actually took the two species together.

The writer's experience on this survey was rather similar to that of Anderson and Potts. *G. longipennis* did not appear to avoid the lesser Kiboko, but seemed to be sheltering in the bush on its banks. Specimens were also collected at night between rivers, and in the drier savanna. There were, however, always small thickets or stretches of dense bush in the neighbourhood which seemed to lend support to the thought that *G. longipennis*, like most other species of tsetse-flies, is sometimes forced to retreat to the shelter of thickets or riverine forest, and that it cannot always withstand the dryness and heat of the so-called semi-desert.

It has become a matter of routine in most fly surveys in Kenya to determine the distribution of the breeding-places of the tsetses. Such surveys are often undertaken at times of the year when the flies are scarce and may have returned from dispersal areas to their permanent haunts, and it is frequently difficult to recommend measures for the protection of stock in localities near the fly-belts.

The finding of puparia outside the infested zone may indicate the most favourable routes of dispersal, the tendency of the fly to establish itself in additional country, and provide evidence on the extent of seasonal spread.

The Breeding-places of *G. longipennis* (Plate IV).

The sites which seemed to be most favoured for larviposition by *G. longipennis* were logs, leaning tree-trunks, and the stumps of felled trees near shrubby or woody thickets. They were also found in open country many hundreds of yards from dense bush, and in the shade of single trees in the savanna. Plate IV, fig. 2, shows a number of dead tree-trunks just outside the thicketed bush on the banks of the greater Kiboko River. Under all these fallen trees, many puparial shells were found; and in the site shown in Plate IV, fig. 3, 33 empty and 4 full puparia were discovered deeply buried in the very friable soil of a mound. Another large collection of 51 empty and 9 full puparia was obtained within an inch or two of the surface under a log in the shelter of a large *Acacia mellifera* on the outskirts of bush along the lesser Kiboko. Still further in the savanna, a smaller batch of 4 puparia was found under a reclining trunk not protected by vegetation; and in the savanna proper, 2 full puparia were taken at the base of a small stump amidst low shrubs (Plate IV, fig. 4).

Numerous other sites were located throughout the *Commiphora-Acacia* savanna; but the puparia were not so abundant as in the breeding-places situated near the denser bush. Larvae had been deposited in similar situations in the much more open country stretching for about two and a half miles north of the greater Kiboko, an area where prolonged patrols by the fly-boys failed to produce flies on the wing.

The thick bush on the banks of the rivers did not appear to furnish suitable conditions for larviposition. Puparia of *G. pallidipes* were common. Only in one situation within thickets were the puparia of *G. longipennis* found. Two were collected under a fallen tree, but they were found in a more exposed patch than 4 puparia of *G. pallidipes* at the base of a multiple-stemmed shrub. In some cases the flies had deposited their larvae underneath strips of bark and at the tufted bases of grasses around logs and stumps.

The Puparium of *G. longipennis* (Plate V).

The unhatched puparia collected were very much unlike those of other tsetse because the posterior notch was absent. A number were put into separate tubes, and within 48 hours adult *G. longipennis* emerged from two of the puparia. More adult flies emerged later.

The puparium is black and large, like those of *G. brevipalpis* and *G. fuscipleuris*. Most of the specimens were larger and more robust than the puparia of the latter, but one specimen was somewhat smaller. In shape, that of *G. longipennis* is egg-like, its greatest width being in the anterior third. The length ranges from 7.6 to 8.5 mm., and the greatest width measures about 4.5 to 5 mm. The posterior lobe is cylindrical, from 1.10 to 1.32 mm. long and from 1.60 to 1.80 mm. broad. The outer surface is ridged (Plate V, fig. 4) and contrasts strongly with the surface of the lips in other species. The notch, so prominent a character in other tsetse, is absent but for a very slight concavity hardly visible to the naked eye. The posterior opening (Plate V, fig. 5) of the stigmatic cavity is roughly circular and from 0.63 to 0.74 mm. in diameter. It is situated in a shallow depression, and surrounded by a narrow flange or rim.

Acknowledgments.

The writer acknowledges with gratitude the assistance given by Sir Guy A. K. Marshall, C.M.G., F.R.S., in arranging for the photographs of the puparia; and by Mr. D. C. Edwards, Senior Agricultural Officer of Kenya Colony, in identifying the grasses mentioned in the text.

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EXPLANATION OF PLATE IV.

- Fig. 1.—*Commiphora* spp. encountered in the Voi-Makindu fly-belt.
- Fig. 2.—Dead tree-trunks just outside of the thicketed bush on the banks of the greater Kiboko River. Many empty puparia were found beneath these tree-trunks.
- Fig. 3.—Fallen tree beneath which empty and full puparia of *G. longipennis* were found.
- Fig. 4.—Full puparia were taken at base of small stump amidst low shrubs in the savanna proper.



Fig. 2.



Fig. 4.



Fig. 1.

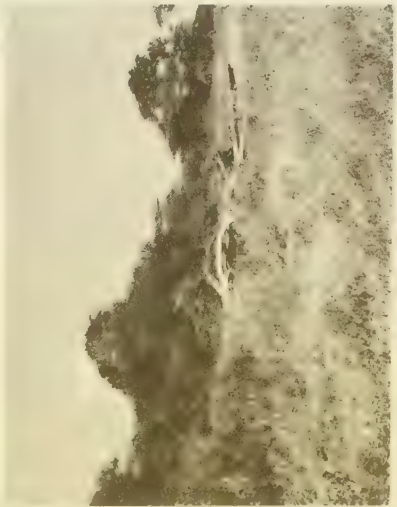


Fig. 3.

BREEDING PLACES OF *GLOSSINA LONGIPENNIS*.

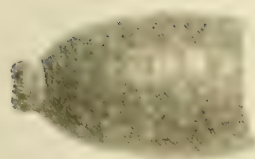


Fig. 1. Dorsal view.

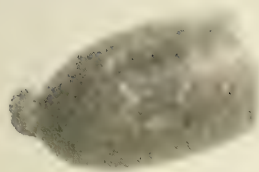


Fig. 2. Side view.

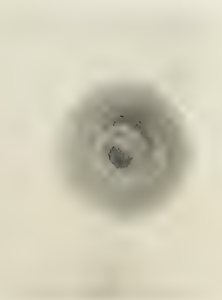


Fig. 3. A view of the posterior stigmatic cavity.



Fig. 4. Ventral view of posterior lobe

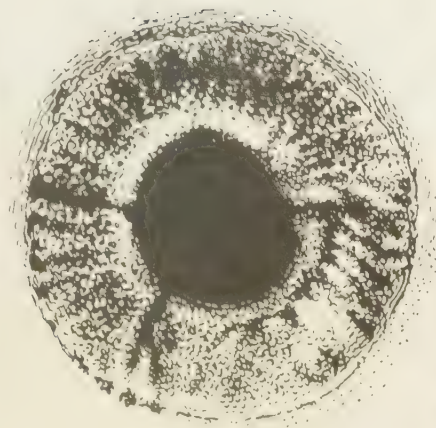


Fig. 5. Posterior view of stigmatic cavity.

THE PUPARIUM OF *GLOSSINA LONGIPENNIS*

STUDIES ON INSECTS BRED FROM BARLEY, WHEAT, MAIZE AND OATS.

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author's corrections
4/7/42

Introduction.

Following a short investigation of insects infesting barley in 1937 (reported in 1939), studies have been made of species found in cereal crops from 1939 to 1941. With the exception of sweet maize grown in a garden near Guildford, Surrey, the crops studied were grown on experimental plots and on the farm of the Lord Wandsworth College Estate in north-east Hampshire.

The present paper gives various facts relating to the biology of eight species of Chloropid flies, four Agromyzids, one Muscid and one Chrysomelid beetle, whose larvae have been found to live in the tissues of the stems, leaves or ears of cereal plants. Most of these forms attack living tissue, but in the case of at least two of the Chloropids the larvae live wholly or partly on the dead remains for which some of the other species are responsible.

The following account adds to and in some degree modifies, at least in regard to conditions in Southern England, Mesnil's recent comprehensive description (1935-6)* of the external features and habits of the insects injurious to graminaceous and other crops.

Some of the data also represent additions to the list of flies infesting given host-plants compiled by Ségué (1934).

Methods of study have included the dissection of freshly collected plants, the rearing of larvae thus found, and the keeping of plant material in cages either as whole plants in pots of soil, or as cut shoots standing in a little water. Some attempt has been made to study the material statistically.

I. BARLEY.

1. A small experimental late spring-sown Plot, 1939.

On 12th May, a small plot of about 72 square feet was sown with Plumage Archer barley. No manurial dressing was applied.

Attack by Coleopterous Larvae.

About a month after sowing, it was noticed that the central leaf in some of the young plants had turned white. Sixteen of these plants were found and dissected between 19 and 23.vi. An *Agriotes* larva was found in the soil under one of them which, with some others, appeared to have been attacked by Elaterid larvae.

In four plants a Coleopterous larva of another type was present. Twelve contained no insect. These larvae all appeared to belong to the same species. One of the four plants (a typical example) had three tillers, in the second and third of which the central leaf had turned yellow. In the main shoot the central leaf was pale and withered. The bases of the two affected tillers were found to be soft and rotten. When they were removed, a small round hole was seen in the base of the main shoot and the hind end of a

* This work was published under the joint authorship of Balachowsky and Mesnil, but Dr. F. I. van Emden informs me that the part on the Dipterous pests of cereals is due to Mesnil, and I use his name in referring to it throughout this paper.

larva was noticed disappearing into it. When some of the plant tissues round the hole were removed, a larva of the kind present in the other three plants was found. The adult bred from this larva proved to be *Chaetocnema arida*, Foudr. (Chrysomelidae); I am indebted to Dr. K. G. Blair, of the British Museum (Natural History), who kindly identified it. I understand from him that this species has been confused by British collectors (as for instance in the Power collection) with *Chaetocnema confusa*, Boh. Specimens of this larva have been retained by the British Museum. Little is known of its life-history, but Dr. Blair informs me that it is usually found in swampy places and is said to feed on *Carex* and *Juncus*. Curiously enough it occurred at Long Sutton on high ground consisting of clay with flints overlying chalk.* There had been little rain during the preceding month. In one shoot the exo-skeletons of two thoracic legs, practically identical with those of the *Chaetocnema* larva and other black fragments, possibly those of the black pronotum, were found. It appeared from this that a larva had moulted and left. The larvae evidently migrated from shoot to shoot, burrowing into the base and doing damage resembling superficially that done by the larva of *Oscinella frit*, L., to oat seedlings.

So far as I am aware, *C. arida*, Foudr., has not hitherto been recorded from cereal crops, but Newton (1929) reports *C. hortensis*, Geoff.,† to have occurred in barley in Britain. The larvae caused much the same type of damage. Balachowsky & Mesnil (*l.c.*, p. 805) give a figure of the larva of *Chaetocnema aridula*, Gyll., which is similar, and Newton (*l.c.*) gives drawings of the larva of *C. hortensis*, to which it also bears a strong resemblance.

Infestation by Chloropids.

At the end of July, 60 stunted shoots were found in the plot. They represented about 4 per cent. of the total number, an unexpectedly low proportion for a late-sown crop. Of these shoots 52 were placed in a jar with a little water in the bottom and this was kept in the laboratory in a large cage consisting of a rectangular glass case 26×37×52 cm., over the open top of which was tied a layer of thick cellophane.‡

The contents of the tank were examined on the dates given in the following table of notes which roughly indicate the succession in which the different species emerged.

10.viii	No adults had appeared.
15.viii	6 <i>Chlorops pumilionis</i> , Bjerk., adults seen; none dead.
22.viii	11 <i>C. pumilionis</i> adults found alive; 8 dead.
28.viii	2 <i>Elachiptera cornuta</i> , Fall., adults found alive, none seen on 23 and 26.viii.
31.viii	7 <i>Lasiosina cinctipes</i> , Mg. No living <i>Chlorops</i> seen.
6.ix	2 <i>L. cinctipes</i> alive.
7-8.ix	2 <i>Camarota curvinervis</i> , Latr., appeared and were removed from the cage on 8.ix. One escaped but the other was killed and mounted.

* A single *Chaetocnema* larva, larger than the above but possibly of the same species, was found on 22nd July, 1940, in a stunted barley shoot in a farm crop. The soil of this field (Maysdown) was dry and chalky. Unfortunately the larva died before pupating.

† = "*C. hortensis* Weise" of Newton's paper.

‡ When dismantling the cage on 20.ix.39, two small holes were found in the corner of the cellophane cover nearest the window. These were almost certainly made by *Stenomalus micans*, Ol. (Hym. Pteromalidae), which normally bites its way through the sheathing leaves of barley shoots. The holes formed a "sieve," through which a number of Chloropids in addition to the Pteromalids escaped. (Incidentally it has been found that *Stenomalus* cannot bite its way through a woolly material, such as a cottonwool plug or thick flannel cloth, on which its mandibles cannot get a sufficient grip.)

12-20.ix The shoots were dissected and the puparia found, together with the adults remaining dead on the bottom of the cage, were as follows:—

C. pumilionis 33 puparia, 25 adults.

L. cinctipes 47 " 16 "

E. cornuta 11 " 6 "

No puparia of *C. curvinervis* were found.

The *Camarota* adults had a remarkable appearance in that the colourless wings, which showed a small pleat in the median-cubital region when at rest, were bent down close to the shining black dorsal surface of the abdomen so that the insects somewhat resembled small black beetles or wingless Psocids. The long thick black aristae which were held erect, resembled filamentous antennae. They moved in vigorous jumps like flea-beetles (*Phyllotreta*). Possibly there is a protective resemblance of some kind.

Mesnil (*l.c.*) states that *C. curvinervis* lays its eggs on rye, wheat and barley, during May in the region of Paris, the adults of the next generation emerging about 10th July. From this it seems likely that the above specimens represent a second summer generation.*

It was noticed that the puparia of *Elachiptera* could be readily distinguished from those of *Lasiosina* in that the posterior spiracles of the former tapered from a broad base, were strongly divergent and not enlarged at the tips, whilst those of the latter were straight sided, only slightly divergent and were enlarged at the tips.

The difference between the number of puparia and the number of flies found in the cage gives an indication of the number of flies which escaped through the holes made by *Stenomalus*. In the case of *Chlorops*, some pupae had probably produced parasites, although *Stenomalus* usually destroys the larva just before it pupates. *Coelinius niger*, which always emerges from the puparium, may have been present although it was not seen. Evidently the holes in the cellophane were too small for most of the *Chlorops* individuals to pass through, the thorax of the female being much broader than any part of the body of either parasite, but possibly some of the males, which are considerably smaller than the females, did escape. This method by which the parasites escape, whilst the females of *C. pumilionis* are retained, may conceivably be of use in controlling the latter. A suitable metal sieve could replace the cellophane. Tests have shown that a perforated tinfoil sieve, with holes 1.3 mm. in diameter, retains *Chlorops* (males and females) but allows all *Stenomalus* to escape. *Coelinius*, however, would not go through a hole smaller than that through which *Chlorops* can pass, although it is much slimmer than the latter; presumably because of its long unwieldy antennae.

If all the infested shoots were collected from badly infested fields and only the Chalcid parasites allowed to escape by the above method, the resulting increased proportion of parasites to gout flies would presumably result in a high percentage of parasitization of the winter generation of *Chlorops*, so that very few of the latter would survive to lay eggs on the next crop of spring barley. *Stenomalus* normally parasitizes between 30 and 40 per cent. of the summer generation of *Chlorops*; *Coelinius* about 20 per cent. This applies to 4 out of 5 years studied, but in 1941 a sample of 75 gouted shoots yielded only 10 *Stenomalus* with 19 *Coelinius* and 46 *Chlorops*. Thus the proportion of Chalcids per gouted shoot (13 per cent.) showed a significant drop below 30 per cent.

2. A Farm Crop, 1939.

A farm crop of barley grown on the Sutton Common fields of the College Estate, Long Sutton, Hampshire, was sown on 20th March. The seed was an impure strain of the variety Plumage Archer.

* Séguy (*l.c.*) mentions that the species is found in oats, and the present author has bred a specimen of it from oat shoots, the adult emerging on 5.viii.41 (see below under "Oats").

The results of the dissection of stunted shoots, gathered at two different periods along the northern and western margins of the fields where the plants grew less vigorously and where infestation was heavier than elsewhere, are summarised as follows:—

	In 40 infested shoots, collected on 14.vii and dissected between 14 and 25.vii	In 28 infested shoots, collected on 26.vii and dissected between 4 and 8.viii
<i>Chlorops</i> ...	4 larvae 23 pupae (none had hatched)	0 larvae 10 puparia (all empty but two)*
<i>Lasiosina</i> ...	24 „ 0 „	23† „ 13 pupae (none had hatched)
<i>Stenomalus</i> ...	7+4§ „ 1 pupa	1 „ 9 pupae (none had hatched)

* The two unhatched puparia contained dead pupae.

† It is possible that some of these larvae were those of *Elachiptera* which are difficult to distinguish from those of *Lasiosina*. However, adults bred from many of them were invariably of the latter species.

§ Four larvae of this parasite were still inside *Chlorops* pupae; the other seven had emerged from their host.

The above results indicate that on the average there was a gap of about a fortnight between the date of pupation of *Chlorops* and that of *Lasiosina*. It is noteworthy that, with only one exception, the presence of free *Stenomalus* larvae, which Kearns (1931) has found to emerge from their host at the beginning of its pupal phase, is contemporaneous with the pupal phase of *Chlorops* but not with that of *Lasiosina*. Although the numbers are too small to be highly significant, this gives some support to the view that *Stenomalus* did not parasitize *Lasiosina* except possibly to a very small extent. This view is the opposite to that expressed in regard to the 1937 infestation (Goodliffe, 1939) but which further study of more material has shown to have been incorrect.

This revised view is also supported by the following argument based on data obtained during 1937, 1939 and 1940. In the detailed examination of 95 *Chlorops*-infested shoots (22 in 1937 and 73 in 1939), in no case was more than one *Chlorops* specimen found in a single shoot. In 28 of these cases (6 in 1937 and 22 in 1939), *Chlorops* was accompanied by one or more specimens of *Lasiosina*. Moreover in 5 other cases there was an average of 5 *Lasiosina* specimens to one *Chlorops*. Furthermore in 9 cases in which *Lasiosina* only occurred in a shoot, there were 2 or more individuals present. In view of these facts, one would have been practically certain to find more than one *Stenomalus* in some shoots if the latter were habitually parasitizing *Lasiosina*. But *Stenomalus* has only been found to occur singly in stunted shoots. This was the case with no exception for 48 shoots (27 in 1937, 21 in 1939).

In 1939 about 15 *Lasiosina* larvae were bred to adults and in no case was a parasite present. In 1940, 18 *Lasiosina* larvae were reared to adults but no parasite appeared. Nor was any parasite found when 20 larvae were dissected in normal saline in the manner employed by Kearns (1931) for *Chlorops*. No parasites were found amongst the adults emerging from a total of 74 known *Lasiosina* pupae during the years 1939–41.

Another argument formerly used by the present author (1939) to support the view that *Stenomalus* parasitized *Lasiosina* in 1937 was based on the wide variation in size of *Stenomalus* adults bred from stunted shoots. This applied the fact that *Lasiosina* is a smaller form than *Chlorops* and assumed that the size of the parasite

was proportional to the size of the pupa on which it had fed. This assumption is difficult to verify, since the *Stenomalus* larva badly damages the integument of the host so that it cannot be measured, but it has been found to be a rough approximation in the case of *Coelinius niger* (fig. 1). (In this investigation, the puparia were measured with a travelling microscope to the nearest 0.05 of a millimetre. The head-breadth of *Coelinius* was measured by the same method as that used for *Stenomalus* and described below.)

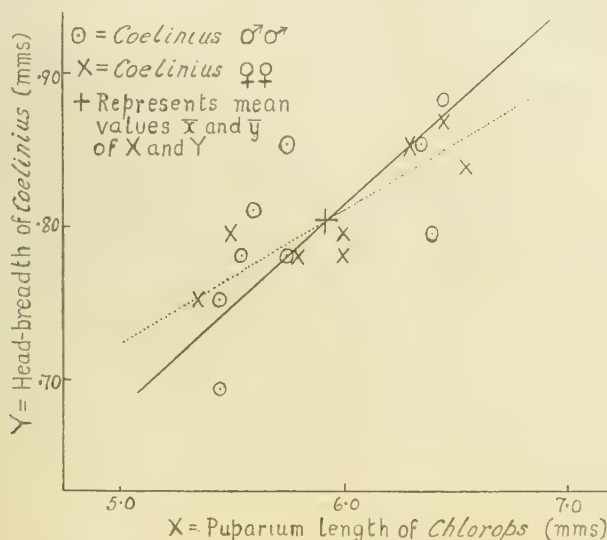


Fig. 1. Head-breadth (Y) of *Coelinius* adults and puparium length (X) of the host *Chlorops*. The unbroken straight line has been fixed by the origin and the point + ($\bar{x} = 5.92$, $\bar{y} = 0.797$). The dotted line shows the regression of Y on X determined by the method of least squares. The correlation coefficient (r) = 0.74; the t test shows this to be highly significant.

On examining more material, one has observed a marked *sexual dimorphism* in *Chlorops pumilionis* in regard to size. Thus the 25 adults bred from shoots of the experimental plot could be readily divided without measurement into two size groups, 12 being smaller than the other 13. An examination of the external genitalia showed that the group composed of the smaller specimens consisted entirely of males and the other group of females. The difference in size between the male and female puparia was equally marked. This difference is quite sufficient to account for the wide range of variation in the size of the *Stenomalus* adults observed in 1937. In *Lasiosina* there was no appreciable difference in the size range of the sexes.

The relative sizes of the Chloropid puparia and *Stenomalus* adults have now been reinvestigated, using greater numbers of specimens and greater precision of measurement. Specimens obtained in both years were pooled and the measurements treated statistically. In order to avoid the complication of possible sexual dimorphism in *Stenomalus*, only the females, which were the more numerous, were used. Owing to shrinkage and inconstancy of the position of the abdomen when mounted, it was decided to abandon body length and use head breadth as the index to relative size. The heads were removed and mounted facing upwards on thick celluloid. An

image magnified 210 times was focused on a screen by using a microprojector and measured to the nearest tenth of an inch. A tenth of an inch represented 0.012 mm. on the actual specimen. When each head was measured it was in the centre of the field. Thirty-two female heads (all available) were thus measured. The puparia were mounted on white card and their images were focused on a screen from an episcopes at a magnification of 12. Not all specimens were in the centre of the field when measured but variation in magnification due to spherical aberration of the image did not exceed 5 per cent. This degree of accuracy was found to be sufficient to give significant differences in the size distribution between the species. The images of 77 *Lasiosina* and 72 *Chlorops* puparia were measured to the nearest tenth of an inch. A tenth of an inch represented a length of 0.21 mm. on the specimen.

Frequency histograms of these measurements are given in fig. 2, in which 87 head-breadth units are made to correspond with 34 units of puparium length, these being the maximum mid-class values for the two variates (on the assumption that the largest *Stenomalus* specimens develop from the largest *Chlorops*). It is remarkable that when this is done, the maximum frequency values and proportional ranges of variation in these variates for *Stenomalus* females* and *Chlorops* puparia respectively show close correspondence; at the same time there is no such correspondence between the values for *Stenomalus* and *Lasiosina*. This again supports the view that *Lasiosina* was not parasitized by *Stenomalus*. Even if this were not the case, and the size of the parasite did not depend upon the first power of the length of the host pupa, one would at least expect a significant bias to the left in the distribution of *Stenomalus* head-breadth.

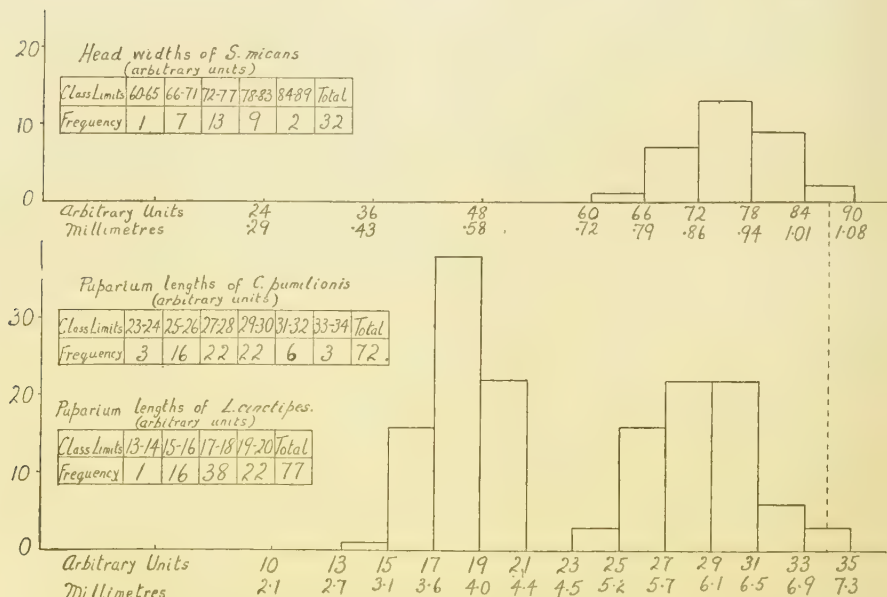


Fig. 2. Distribution of head-breadth in *Stenomalus micans*, Ol., and of puparium length in *Lasiosina cinctipes*, Mg., and *Chlorops pumilionis*, Bjerk.

* The head-breadth for 10 males was also determined and found to be within the range of variation for the 32 females. The mean value for the males was 0.876 mm. and that for the females 0.902 mm. The difference, having a standard error of 0.022 mm, is not significant.

The strong bias to the left shown by the distribution of length for the *Chlorops* puparia is to be expected from the fact that the mean length of the males is considerably less than that of the females—assuming that the size range of the males is smaller than that of the females.

3. A Farm Crop, 1940.

A field (Maysdown) which had been a pasture for many years was ploughed up in the autumn of 1939 and sown with winter wheat. The crop failed owing to a heavy attack of wireworm (*Agriotes*).

It was then planted with Plumage Archer barley on 18-19th April, 1940, and this crop was heavily infested with *Chloropids*. On 12th July by the use of a method of random sampling, which unfortunately proved to be rather rough, the average percentage of stunted shoots was found to be 20.4 ± 3.2 (standard error). Thus one can only say with confidence that the extent of infestation was at least 10 per cent. That it was probably much nearer the mean value is suggested by the fact that occasionally one found plants consisting of 4 or 5 shoots with every shoot infested. This only applies to the side of the field which slopes to the north-west and on which the soil overlying solid chalk was only about 30 cm. deep. At the foot of the slope, where the soil was deeper and probably moister and richer in plant nutrients, the barley grew much more vigorously (some of the wheat also survived) and very few shoots were infested. This means that injury due to *Chloropids* was heaviest where *Agriotes* was also doing most damage.*

On 29th July, 225 dead, yellow, stunted shoots were gathered from this field and placed in a cage consisting of a large glass tank (such as was used in 1939), over the top of which was tied a piece of thick flannel. About 10th August, in the corner of this flannel nearest the windows of the laboratory, a hole was cut into which was tightly fitted the open end of a large test tube (1 inch in diameter). The tube rested nearly horizontally but sloped towards the hole. It was found to provide a convenient means of sampling the insect population in the cage, since specimens tended to congregate in the tube owing to positive phototaxis. Table I gives an analysis of samples taken at various dates:—

TABLE I.

	From ca. 8—13.viii	15.viii	18.viii	20.viii	21.viii	27.viii	2.ix	4.ix	6.ix	7.ix
<i>Lasiosina</i>	2(<u>1</u>)	0	8(<u>1</u>)	8	8(<u>1</u>)	12(<u>1</u>)	11(<u>3</u>)	25(<u>3</u> / <u>16</u>)	25(<u>1</u>/<u>16</u>)	4
<i>Chlorops</i>	38(<u>2</u> / <u>3</u>)	17(<u>5</u> / <u>13</u>)	15(<u>9</u> / <u>15</u>)	4(<u>2</u>)	2(<u>2</u>)	0	0	0	0	0
<i>Elachiptera</i>	0	0	0	0	2	3	26(<u>1</u>/<u>3</u>)	3	4	4
<i>Stenomalus</i>	12	7	10	1	5(<u>1</u> / <u>4</u>)	7(<u>1</u> / <u>3</u>)	4(<u>2</u> / <u>4</u>)	3(<u>2</u> / <u>3</u>)	1(<u>1</u> / <u>1</u>)	
<i>Coelinius</i>	15	4	9	1	0	0	0	0	0	0

Fractions in brackets are $\frac{\text{numbers of males}}{\text{number of females}}$ —this was not always noted.

Numbers underlined represent periods of maximum rate of emergence. It is curious that *Lasiosina* had two such periods. After 7.ix very few insects appeared. It is interesting that the males of *Chlorops* were earlier than the females. With *Stenomalus* too, which lags behind its host by about a week, nearly all the later specimens were females.

* A similar case to this was observed in Cricketers Field, which was newly ploughed grassland in 1941.

35 (19/16)

26 (13/13)

The following species appeared in much smaller numbers. The dates given are for the appearance of the first specimens seen.

Meromyza saltatrix var. *nigriventris*, Mcq. 19.viii.40. 1 specimen (2 more emerged from another 355 shoots)

Oscinella frit var. *pusilla*, Mg. 18.viii.40. 4 specimens

Cerodonta denticornis, Pz. 26.viii.40. 3 „

Pseudonapomyza atra, Mg. 11.v.41 4 „ (from another cage of 465 shoots).

The corresponding dates of first appearance for the more numerous species are as follows. This list includes dates of first emergence in cages of shoots gathered earlier than the above, but the total numbers of specimens given are for the above 225 shoots only.

	Date of first appearance	Total numbers of adults hatching	Total numbers taken from sampling tubes
<i>Chlorops pumilionis</i>	22.vii	99	76
<i>Coelinius niger</i>	26.vii	36	29
<i>Stenomalus micans</i>	1.viii	67*	49
<i>Lasiosina cinctipes</i>	8.viii	334	119
<i>Elachiptera cornuta</i>	15.viii	198	38

* In addition, 10 specimens died in the pupal stage.

One empty *Lasiosina* puparium was, however, found in a green shoot as early as 5.vii. No other insect was with it. The larva presumably attacked the shoot at about the same time as the general attack of the *Chlorops* larvae, *i.e.*, during June. In *Chlorops* it is about 9 weeks (Ministry of Agriculture leaflet, 1933) from the hatching of the egg to the emergence of the adult, whilst this period for *Lasiosina* is about 4 weeks shorter. This is mainly due to the remarkably long pupal phase of *Chlorops* (5 weeks) as compared with that of all the other Chloropids studied here, which is about 2 weeks (Mesnil *l.c.*).

That *Lasiosina* larvae began to appear in considerable numbers during July is shown by the following shoot-dissection results.

102 shoots on 5.vii yielded : 241 shoots dissected on 25.vii yielded :

Chlorops 14 larvae—65 pupae *Chlorops* 6 larvae—148 pupae

Lasiosina 1 larva—1 empty puparium *Lasiosina* 34 larvae—9 pupae

That the larval population of *Lasiosina* reached its maximum during the first half of August is indicated by the fact that the maximum numbers of adults appeared in the cage during the first week in September. During August, the larvae acted together with those of *Elachiptera cornuta* as scavengers in gouted shoots. But during July and possibly earlier the rôle of many may have been quite different.

4. Discussion of Observations.

(a) *Ecological Relationships of the Lasiosina Larva.*

Referring back to the results of dissecting shoots from the farm crop of 1939, it can be seen that (as in 1940) most of the *Lasiosina* larvae made their appearance

later than those of *Chlorops*. To give further details, one shoot containing a *Chlorops* pupa also had in it 9 *Lasiosina* larvae of various lengths from 2.5 to 5.0 mm. In 5 other cases, shoots containing *Chlorops* pupae also contained between them a total of 8 *Lasiosina* larvae feeding on the ears.

This association between *Lasiosina* and *Chlorops* may be regarded as a case of synecy in the sense defined by Borradaile (1923), in that the former benefits in its association with the latter by the fact that, in shoots gouted by *Chlorops*, the ear commonly does not emerge from inside the sheathing leaves and so is kept moist and in a suitable condition for its habitation by *Lasiosina*.

Chlorops larvae do not usually make more than a shallow scar down one side of the ear, but they make a deep groove in the ear stalk thus checking its growth and very frequently preventing the emergence of the ear. *Lasiosina* larvae on the other hand are usually found in the ensheathed ear burrowing between the glumes into the unripe grain. Empty egg-shells, almost certainly those of *Lasiosina*, were found, some on the ears and some on leaves.

Evidently the female of *Lasiosina*, unlike that of *Chlorops*,* lays eggs in shoots already infested by one or more larvae of her own species. The length of time elapsing before the infested ear dries up, or is consumed, must be a limiting factor to the number of *Lasiosina* larvae which reach the pupal state. Occasionally dead dried-up *Lasiosina* larvae were found inside sheathing leaves. It therefore seems likely that the greater average number of *Lasiosina* larvae per infested shoot found in 1939 and 1940, as compared with that in 1937, is connected with the continuously wet weather in July 1939 and 1940. Similar considerations apply to *Elachiptera cornuta*. Table II lends support to this view.

TABLE II.

Date of sowing	Date of picking	No. of infested shoots	No. of puparia found in shoots§		<i>Lasiosina</i> puparia per shoot	Rainfall at Long Sutton during July
			<i>Lasiosina</i>	<i>Elachiptera</i>		
27.iv.37	31.vii.37	160	35	1	0.21	20.1 mm. (8 days of rain)
12.v.39	31.vii.39	52	47	11	0.90	101.1 mm. (21 days rain, including every day of last fortnight)
19.iv.40	29.vii.40	225	334	198	1.48	93.4 mm. (rain every week)

§ On examination more than a month later after the adults had hatched in the laboratory.

Dr. H. G. H. Kearns has informed me by letter that in 1928 there was a very small proportion of *Lasiosina* larvae in some 10,000 gouted shoots gathered from South and South-East England at various dates in July up to the 27th of the month. At Long Sutton the rainfall for July 1928 was 22.5 mm.—a dry month.

The variety grown in 1937 was Spratt Archer and that in 1939 and 1940 Plumage Archer, but there seems little reason to believe that this difference would account for the fact that more than four times as many *Lasiosina* adults developed per gouted shoot in 1939 as in 1937. In 1940, when July was again very wet, there were seven times as many.

* Confined in a cage, however, with potted barley plants in the late summer, *Chlorops* females laid as many as 10 eggs per shoot. In one shoot, 9 first-stage larvae were found, 6 of them alive. Several pairs of *Lasiosina* adults, placed in the same cage, did not breed. Umbelliferous flowers were provided to supply food.

That *Lasiosina* is not entirely dependent upon *Chlorops* is shown by the fact that in 1939 in the Sutton Common fields, 7 out of 68 stunted shoots were found in which *Lasiosina* larvae were thriving in the total absence of *Chlorops*. These contained a total of 21 larvae and pupae of widely varying ages. None of these shoots was typically gouted, i.e., there was very little swelling of the nodes and internodes. In two cases there was a deep groove in the ear-stalk in which larvae were feeding and thus delaying the growth of the stalk in the manner of a *Chlorops* larva already described. One must admit that at least in these two cases it is just possible that a *Chlorops* larva had been present but had already been destroyed by a *Stenomalus* which had become adult and left the shoot. In 1940, four more cases of pure *Lasiosina* infestation of a shoot were found. In one case particularly it seemed very unlikely that a *Chlorops* larva could possibly have developed in the shoot, since the ear and its stalk seemed to have been very small when attacked and could hardly have provided enough nourishment for two larvae. This was a green living shoot.

The question of the extent to which *Lasiosina* can act as a primary pest still remains open. It has been reported as a pest of barley (under the name of *Chlorops limbata*, Mg.) in Kent by F. V. Theobald (as quoted by Warburton, 1922) and in Bulgaria by Drenowsky (1923). These reports do not indicate the relative size of any *Chlorops pumilionis* population that may have been present, except that in Kent *Lasiosina* is stated to have been the main cause of stunting. It seems possible that if *Chlorops* were practically absent, owing for instance to very heavy parasitization of the last two generations, then in July *Lasiosina* might attack quite a large proportion of the later tillers of a late-sown or backward crop. The study at Long Sutton of the barley crops of three years in which *Chlorops* was abundant has indicated that between 5 and 10 per cent. of the stunted shoots were attacked primarily by *Lasiosina*. This is in disagreement with Mesnil (*l.c.* p. 983) who believes Drenowsky to have made an error of observation and states that *Lasiosina* is invariably "detriticole" and only attacks barley shoots which have already been attacked by *Chlorops pumilionis*.

(b) *Significance of the Appearance of Infested Shoots.*

Since 1937, after examining more material, it has been realised that deductions from the appearance of infested shoots must be made with great caution. In 1939, although usually the upper nodes and internodes of shoots infested by *Chlorops* were much swollen, and those attacked only by *Lasiosina* considerably less or not at all swollen and so not typically "gouted," the opposite to the usual was found to occur for both species in a few cases. Thus a few shoots containing *Lasiosina* alone were as much swollen as was often the case when *Chlorops* was present. In a few other instances, shoots containing *Chlorops* larvae were as little swollen as was usual with *Lasiosina* only. The region above the last node, when the ear was ensheathed in leaves, frequently had a bulky appearance in shoots infested by either species.

These facts nullify the present author's conclusion (*l.c.*) in the case of the 1937 infestation that *Stenomalus* specimens found in "ungouted" shoots had probably developed in *Lasiosina* larvae.

Drenowsky (1923) gives a good drawing of a typical example of a shoot infested by *Lasiosina* only. He states, however, as quoted by Duda (1932-3, p. 138), that the length of the ear-stalk is typically less than 2.5 mm. (as compared with 30-100 mm. for infestation by *Chlorops*). This has only been true for about half the cases found at Long Sutton. In these, the ear and its stalk had been severely attacked before much developed and had been nearly completely demolished. *Chlorops* larvae on the other hand have always been found to allow the young ear to develop to a considerable extent. This is presumably because they live purely by absorbing sap during most of their early life, which they spend just above the uppermost nodes (Mesnil *l.c.*, p. 940).

TABLE III.

	Length in mm. of				Diameter in mm. of				Date of measuring
	ear stalk	last internode but			top node	last node but			
		one*	two	three		one	two	three	
Uninfested shoots	166	121	68	75	3	4	4	5	9.vii.40
	159	115	43	62	2	2	3	4	
	145	120	67	62	2	2.5	3	3	
	142	100	58	58	3.5	3	2	5	
	116	110	75	60	5	3	2	2	
	160	116	58	60	2	2	3	4.5	
	175	115	65	64	3	3	3	3	
Average ...	152	114	62	63	2.9	2.9	2.9	3.8	
Attacked by <i>Chlorops</i> at an early stage	38	2	4	1	4	3	1	1	9.vii.40
	36	2	4	—	5	3	1	—	
	44	1.5	2	<1	3	2	2	<1	
	40	2	4	<1	4	3	1	<1	
	21	9	6.5	<1	2	4	4	1	
	51	22	<1	—	3	4	3	—	
	31	1	4	<1	4	3	3	<1	
Averages ...	37	6	4	<1	3.6	3.1	2.1	<1	
Attacked by <i>Chlorops</i> at a relatively late stage in development	40	1	50	40	5	4.5	2.5	2.2	15.vii.40
	25	5	40	40	5	1	1	1	
	62	10	32	45	2	5	3	3	
	40	5	45	30	6	3	3	2	
	35	2	22	46	6	4	2	3	
	90	4	50	40	3	3	3	2	
	35	2	25	45	5	5	3	2	
Averages ...	47	4	38	41	4.6	3.6	2.5	2.2	
Attacked by <i>Lasioides</i> only at various stages in development as indicated by lengths of the lower internodes	51	2	3	4	2.5	3	3	3	15.vii.40
	59	5	9	—	3	3.5	3	—	18.vii.40
des-troyed	—	2	2	19	1.8	2.0	2.2	2.0	22.vii.40
"	—	3	5	5	—	—	—	—	7.viii.39
65	6.5	28	—	3	2.3	2.4	—	—	
	<6	<6	—	not swollen	not swollen	—	—	—	
—	6	—	—	—	3.0	3.0	—	—	8.viii.39
4.0	6.0	4.5	—	—	1.5	1.8	2.5	—	
75	5	5.0	—	—	3.0	3.4	—	—	
—	2	2.0	—	—	3.0	4.0	4.3	—	
Averages ...	51	4	7	9	2.6	2.9	2.9	—	
Attacked late by <i>M. saltatrix</i> var. <i>nigriventris</i>	38	5	59	—	5.3	5.6	3.6	—	7.viii.39
...	36	5	44	—	4.7	5.1	3.8	—	
Averages ...	37	5	51	—	5.0	5.3	3.7	—	
<i>Chlorops</i> † ...	broken	3	4	24	1.3	2.9	2.1	2.3	29.vii.40

* The internode immediately below the ear stalk.

† This is an exceptional case in which the nodes were not swollen.

In 5 out of 10 cases of shoots infested by *Lasiosina* only, the ear-stalks had a length of 4, 51, 59, 65, and 75 mm., respectively, *i.e.* far greater than Drenowsky's typical value of 2.5 mm. This length clearly depends upon the stage in growth at which the shoot is attacked, which varies widely in the case of both *Chlorops* and *Lasiosina*. *Lasiosina* larvae have not, however, been found to infest un-
 one attacked shoots at as late a stage of development as can those of *Chlorops*. Not infrequently the uppermost internode was between 40 and 60 mm. long (in 11 out of 65 cases) in pure *Chlorops* infestation, whilst in pure *Lasiosina* infestation this internode did not exceed 6.5 mm. in the 10 cases measured.

Table III gives measurements (in millimetres) made on various samples of shoots picked at random (except for those containing *Lasiosina* only when all obtainable at certain times were taken). The dates of measuring were within a day of the dates of picking except for those measured on 7-8.viii.39 which were collected on 26.vii.39 and kept in water until measured.

(c) *Notes on the Biology of Meromyza saltatrix var. nigriventris, Mcq.*

Two shoots in the Sutton Common Fields, on 7.viii.39, contained only a single pale apple-green pupa. The puparium when empty was white. Practically identical flies emerged from these on 15 and 22.viii. and the species was identified as *Meromyza saltatrix* var. *nigriventris*, Mcq., by Mr. R. L. Coe. The puparia were found attached to the inside of the outermost leaf-sheath but one by a web of silk at the posterior end. This web of silk was not found in the case of any other pupae studied in this investigation. Both shoots were gouted, as in the more extreme cases of attack by *Chlorops*, the uppermost nodes being very swollen and having a diameter of between 5 and 6 mm., whilst that for normal shoots and those only infested by *Lasiosina* rarely exceeded 4 mm. (see table above).

Mesnil (*l.c.*, p. 741) describes three different modes of attack on the plant by *Meromyza saltatrix*, L. The above represents a fourth. He believes *M. saltatrix* var. *nigriventris*, Mcq., to be a winter form, but in North-East Hampshire a total of 6 specimens has been bred in the summers of 1939-40, 5 adults emerging from barley shoots in August and one from wheat in July. None of the paler typical form appeared.

(d) *Sexual Dimorphism and other Variation in Chlorops pumilionis.*

Mesnil (*l.c.*, pp. 959-63) also makes a distinction between a dark winter form and a paler summer form of *Chlorops pumilionis* and gives a coloured plate illustrating the two types, which differ mainly in the length of the median thoracic stripe. Over 100 specimens, bred out in cages at Long Sutton during July and August 1940, have been examined and both the "winter" and "summer" forms have been found amongst them, although most specimens showed an intermediate pigmentation.

C. pumilionis showed another secondary sexual difference in addition to that of size mentioned above, *viz.*, in colour. The underside of the abdomen and the sides of the thorax in the males was a moderately deep yellow (aureolin) but in the females a very pale sulphur yellow (see British Colour Council, 1938). Mesnil (*l.c.*, p. 937) does not mention either a colour or a size difference but describes a sexual dimorphism in the proportional length of the first mid-tarsal joint, that in the male being shorter than in the female when compared with the combined length of the succeeding tarsal joints.

II. WHEAT.

In May 1940, an area of about 100 square yards in a field of winter wheat was found to contain a considerable proportion (but not more than 5 per cent.) of stunted shoots. Leaves ruined by Agromyzid larvae were also not uncommon. The field (Yolk-up-Hyde) had been arable land for many years and had produced a crop of mangolds prior to being sown with wheat, variety Juliana, on 21.ix.39.

Towards the end of May, and early in June, a Dipterous larva could be found in most of the stunted shoots at the base of the earstalk. These larvae agreed well with Mesnil's description for *Hylemyia (Phorbia) genitalis*, Schnabl.

On 21st June, plants bearing stunted but unswollen shoots each with a dead central leaf were dug up and planted in their own soil in flower-pots. Twelve potted plants were placed in cages of the type used for the barley. Other stunted shoots from the same area, dissected at this time, contained no larvae, but two pupae were found which hatched on 10th July, producing adults of a Chloropid species which Dr. van Emden named tentatively *Oscinella ? gracilior*, De Meij. The British Chloropid collection was not available at the time and unfortunately the specimens (except for the puparia) were later damaged beyond recognition in the post.

The absence on 21st June of the Muscid larvae, which had hitherto been easily found, led one to the suspicion (confirmed later) that these had left the shoots to pupate in the ground.

On 13th July, the two cages containing potted plants each contained several flies which were removed and mounted. These comprised the following :—

<i>Elachiptera cornuta</i> , Fall.	...	...	...	11 specimens
<i>Meromyza saltatrix</i> var. <i>nigriventris</i> , Mcq.				1 specimen
<i>Agromyza nigripes</i> , Mg.	...	...	...	1 "
<i>Oscinella frit</i> , L.	...	...	...	1 "
<i>Tropidoscinis albipalpis</i> , Mg.	...	...	...	1 "

No more adults emerged in these cages until the next spring, when the following appeared :—

21.iii.41–4.iv.41.	304 <i>Hylemyia (Phorbia) genitalis</i> , Schnabl.	2 ♀♀ and 1 ♂
19.iv.41–23.iv.41.	3 <i>Agromyza (Domomyza) ambigua</i> , Fall.	
20.iv.41.	1 Braconid, <i>Phaenocarpa pullata</i> , Hal.	

After the appearance of the first *Hylemyia* adult, a female, the shoots were cut off close to the soil and placed in another cage. All the remaining specimens emerged in the cage containing pots minus the shoots, and thus are known to have come from pupae in the soil, in which empty puparia were found later. Thus one may say that *Hylemyia genitalis* and *Agromyza ambigua* pupate at least to some extent in the soil. Mesnil states that the former species pupates in the shoot, without mentioning that it also pupates in the soil. K. Smith (1931) states that it pupates in the soil, but he equates *Phorbia genitalis*, Schnabl, with *Chortophila sepia*, Mg. Karl (1928) describes these as two distinct species, and since Smith does not give Karl's work in his list of references, it seems doubtful whether he had seen it.

III. MAIZE.

In the summer of 1939, a crop of sweet maize grown near Bramley, Surrey, was infested by Chloropids. It was grown in the garden of Gosden House as an experiment under the direction of Sir Daniel Hall, F.R.S., to whom I am indebted for drawing my attention to the outbreak.

Sowing took place about the middle of May, and oats were planted between the rows of maize as a counter-attraction to frit flies. The oat seedlings were heavily attacked, but the maize suffered almost as badly. By the middle of July only a small proportion of the maize plants had survived, and it was evident that Dipterous larvae were a major cause of the failure.

Three stunted plants were dissected in detail on 21st July. In one which had three tillers, the primary shoot showed no sign of insect attack, the first tiller had empty Dipterous egg-shells on the withered ends of the leaves and contained larvae

and one empty puparium, and one other tiller contained a pupa. The second plant consisted of a primary shoot and five tillers. The main shoot contained a larva, the first tiller three pupae and an empty puparium, and one other tiller appeared to have been attacked. The third plant had four tillers. The primary shoot contained two pupae, the first tiller a pupa and the second an empty puparium. Nineteen shoots were placed in a large closed cage and examined on 9.x.39. Fourteen shoots contained no insect remains. In the five others, 14 empty puparia were found.

The following flies were found dead in the cage :—

<i>Oscinella frit</i> , L.	...	...	...	...	...	6 specimens
<i>Aphanotrigonum trilineatum</i> , Mg.*	...	...	...	...	...	6 "
<i>Elachiptera cornuta</i> , Fall.	...	...	...	...	...	1 specimen.

Four specimens of the second species have been retained in the British Museum collection. As far as one is aware, this species has not been recorded as occurring in *Zea mais*. Its larvae, together with those of *E. cornuta*, were presumably feeding on the detritus produced by *O. frit* (see Mesnil, *l.c.*, pp. 986, 990). Roos (1937) reports *A. trilineatum* in association with *O. frit* in barley, oats and wheat, in Switzerland.

IV. OATS.

1, -2 A field (Further/down) which had been grass-land for several years was ploughed up at the end of March and sown with oats, variety Star, on 15-16th April, 1941. X

The crop was infested by Chloropids in addition to being severely attacked by *Agriotes* spp. Large patches were completely destroyed.

On 4th July, 36 infested shoots were gathered and placed in a cage of the type used for barley in 1940. They were kept in a beaker containing about 2 cm. of water, and the adults emerging were removed and counted periodically. The following were obtained during the periods indicated below :—

7-12.vii	...	10 specimens of <i>O. frit</i>	presumed to have pupated between 27.vi and 2.vii.
13-30.vii	...	12 " " "	<i>O. frit</i> presumed to have pupated between 6 and 20.vii.
3-9.viii	...	4 " " "	<i>Lasiosina cinctipes</i> } larvae presumed to have
10-23.viii	...	5 " " "	" " } hatched between 29.vi and 19.vii.
5.viii	...	1 " " "	<i>Camarota curvinervis</i> .

The oat shoots were carefully dissected on 3.ix and 39 puparia of *O. frit* were found. Of these 17 had not hatched. One contained a Chalcid pupa, but some of the others appeared simply to contain Chloropid pupae. In addition, nine empty puparia of *L. cinctipes* and one of *C. curvinervis* were found. Soaking the dead shoots in strong caustic soda and washing aided dissection by rendering them soft, colourless and semi-transparent.

Taking the figures given by Mesnil (*l.c.*, pp. 982, 1002), the average periods of the larval and pupal stages for *O. frit* are 18 and 10 days respectively, and those for *Lasiosina* 22 and 13 days. On the assumption that these figures are applicable in the present case, 12 out of 22 individuals of *O. frit* would have been still in the larval stage when *Lasiosina* began to appear (*i.e.* on 29.vi). Thus the larval stage of *Lasiosina* overlapped that of *O. frit*, but nearly all the larvae of *O. frit* came first.

It seems likely that every infested shoot contained at least one larva of *O. frit* and that the main rôle of *Lasiosina* was to feed on shoots that had already been attacked by the former species.

* Formerly *Tricimba trilineata*, Mg. (see Duda, 1932).

So far as the writer is aware, *L. cinctipes* has not hitherto been recorded either as occurring in oat shoots or in association with the frit fly.

Note on a Chalcid parasite of O. frit.

From two out of seven puparia of *O. frit* collected by Mr. V. J. Porter from oat shoots (not ears) growing on an air raid shelter at Long Sutton in July 1941, two specimens of *Callitula pyrrhogaster*, Walker, were bred out in the same month. This species, which has vestigial wings, is not mentioned on any list of the parasites of *O. frit* with which the writer is acquainted, but Mr. Nixon, of the Imperial Institute of Entomology, when identifying it, was struck by its close resemblance to *Callitula bicolor*, Spin., which has normal wings and has more than once been recorded as a parasite of the frit fly. He suggested that *C. pyrrhogaster* may simply represent a particular phase of *C. bicolor*. One may add that care was taken to ensure that these specimens reached maturity by feeding them on flowers of wild *Pastinaca sativa*, L., and keeping them alive for over a week.

Summary.

Larvae of a flea-beetle, *Chaetocnema arida*, were found mining in the stems of young barley shoots in June 1939.

Chlorops pumilionis larvae infested barley most heavily in fields where *Agriotes* larvae were doing most damage. The *Chlorops* adults showed marked sexual dimorphism in both size and colour. The size range for this species is correlated with a proportionate size range in its parasites *Coelinius niger* and *Stenomalus micans*. Perforations 1.3 mm. in diameter in the top of a cage were sufficient for the escape of *Stenomalus* but not of *Chlorops* or *Coelinius*.

Lasiosina cinctipes larvae were commonly synoecious with *Chlorops* in barley shoots, but in some cases (5-10 per cent.) they were living without *Chlorops*. In these shoots the nodes were not swollen as in *Chlorops* infestation. *Lasiosina* was not attacked by the above parasites of *Chlorops*.

The larvae of *Elachiptera cornuta* infested shoots already badly damaged by other species and were accompanied by many *Lasiosina* larvae. Wet weather in July favours these two species. Their puparia differ in the form of the posterior spiracles. *Elachiptera* also occurred in maize and wheat.

Meromyza saltatrix var. *nigriventris* was present in stunted barley shoots in small numbers, producing swelling of the nodes very like that due to *Chlorops*. The summer pigmentation in both these species in Hampshire differed from that reported by Mesnil in France. *Meromyza* was also bred from wheat. *Meromyza* puparia, unlike those of *Chlorops*, were attached to barley sheathing-leaves by silk.

Oscinella frit larvae, infesting young sweet maize shoots at Gosden, Surrey, were either accompanied or followed by those of *Aphanotrigonum trilineatum* and *Elachiptera*. Infesting oat shoots at Long Sutton, Hampshire, *Oscinella frit* larvae were accompanied by larvae of *Lasiosina* and *Camarota curvinervis*. Adults of the latter emerged from stunted barley shoots in September. They showed some resemblance to flea beetles, possibly protective. *Oscinella frit* was also bred in small numbers from stunted wheat and barley shoots. The Chalcid, *Callitula pyrrhogaster*, was reared from pupae of this species found in oat shoots.

Larvae of a Muscid, *Hylemyia* (*Phorbia*) *genitalis*, infested a winter wheat crop in large numbers in May 1940. *Tropidoscinius albipalpis*, *Oscinella* ? *gracilior* and *Agromyza nigripes*, were bred in small numbers from potted plants of this crop kept in a cage in the laboratory during the summer. *Hylemyia genitalis* and *Agromyza* (*Domomyza*) *ambigua* pupated in the soil surrounding the roots of these plants. The adults (together with a Braconid parasite, *Phaenocarpa pullata*, Hal.) emerged from the soil in the following spring.

Small numbers of two Agromyzid flies emerged from large collections of stunted barley shoots kept in cages in the laboratory—*Cerodonta denticornis*, Pz., at the end of August and *Pseudonapomyza atra*, Mg., in May of the next year.

Acknowledgments.

The identity of the species dealt with in this paper is based upon determinations of representative specimens kindly made by specialists. To Dr. K. G. Blair (B.M.)* I owe the determination of the Coleoptera. The late Dr. F. W. Edwards (B.M.) identified *Chlorops pumilionis* and *Lasiosina cinctipes*. Mr. R. L. Coe (B.M.) determined the species of all the other Chloropids except for some specimens of *Oscinella frit* var. *pusilla* identified by Dr. F. I. van Emden (I.I.E.),† to whom I am also indebted for valuable advice on points of technique and help with German translation. To him, too, I owe the identification of the Muscid species and of *Cerodonta denticornis* and *Agromyza nigripes*. Dr. Charles Ferrière (I.I.E.) identified the Chalcid and Mr. G. E. J. Nixon (I.I.E.) the other parasitic Hymenoptera. Finally, to Mr. J. E. Collin I owe the determination of *Agromyza* (*Domomyza*) *ambigua* and *Pseudonapomyza atra*. Without the co-operation of these gentlemen this work would have been impossible, and I much appreciate their assistance.

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* B.M.=British Museum (Natural History).

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A STUDY OF THE CAUSES LEADING TO THE SEASONAL EVACUATION OF A TSETSE BREEDING-GROUND.

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(PLATE VI.)

Introduction.

In 1939 the writer published an article in this journal entitled "The Ecology of the Puparium of *Glossina* in Northern Nigeria" (Nash 1939). He described the seasonal shifting of the breeding-grounds of *G. morsitans* and *G. tachinoides* at Gadau, and, after discussing the relationship between certain meteorological data and pupal mortality, he summed up on p. 281 as follows: "It has been shown that the females leave a breeding-ground as soon as pupal mortality starts to increase, and that this coincides with rising soil temperature in the dry season and with rising soil water content in the rains; but no explanation has been given as to what prompts the female to vacate a breeding-ground when she does."

The purpose of the investigation described below was to try to discover why the female evacuates a dry season breeding-ground at the time when increasing soil temperature is associated with an increasing pupal mortality.

Description of the Breeding-Ground selected.

Out of the seven breeding-grounds previously described (Nash 1939, p. 262) Taylor's Forest Island was selected because during every February and March the breeding shifts some 40 yards from the edge of the forest to the centre. In the absence of a continuous peripheral thicket, tongues of true forest extend in places to the island's margin, and it is in such places that breeding starts in the early dry season when the centre of the forest is still sodden. By the end of March the climate of the forest fringe has become too severe and puparia can only be found in dense patches of intrusive thicket in the centre.

Site no. 1 is about 30 yards in from the actual forest edge and is characterised by a high-shade canopy which has suppressed almost all undergrowth (Plate VI, figs. 1, 2). The meteorological records for Taylor's Forest Island which were published in 1939 were taken at this site, and the puparia found throughout the island were buried in this spot.

Site no. 2, the centre of the forest island, is situated in a dense patch of intrusive thicket which clambers over medium-sized trees. This site is shaded on the east by a curtain of living creeper, and on the west by a mat of dead creeper whose leafless stalks support an accumulation of decaying debris for the first eight feet above ground-level.

Methods employed in the Investigation.

An area of 250 square yards was demarcated for puparia-searching round the meteorological station which forms the centre of each site; unfortunately the effective area of search was considerably less in site no. 2 owing to the impenetrable clumps formed by the woody stems of brambles and creepers.

On the 19th day of each month four highly-skilled puparia boys spent 4 hours looking for puparia in site no. 1, and on the 20th in site no. 2. At the end of each day's search the puparia were poured down a projecting glass tube on to soil in a

copper-gauze chamber, which lay buried $1\frac{1}{2}$ inches beneath the soil surface. The tube was then re-corked. (For description of chamber *vide* Nash 1939, p. 261.) The light from the top of the projecting glass tube attracted the emerging tsetse; ten days after the last fly had been observed, the chamber was dug up and the emergences recorded.

The following meteorological data were obtained from each site :—

1. At 4 feet. Maximum and minimum shade temperature from a thermohygrograph in a Stevenson screen.
2. At 4 feet. Evaporation, using a Livingston white atmometer bulb.
3. At 5 inches. Evaporation, using a Livingston atmometer bulb.
4. At surface. Maximum shade temperature. The thermometer was kept on the ground and was screened by a log 3 feet long, 15 inches in circumference, raised 4 inches above the surface, and orientated east and west. To prevent the sun's rays falling on the bulb at the times of the solstices, two screens were fixed six inches above ground-level along the north and south sides of the log, but not touching it; hence no obstructions were offered to surface air currents. (Plate VI, fig. 3).
5. At $1\frac{1}{2}$ inches depth. Maximum and minimum soil temperatures. The bulbs of the thermometers were buried beside the puparia chamber and could be read without disturbing the soil. The maximum thermometers were of a type which will hold their readings in a vertical position, and the minimum were specially made with the bulb placed at the end of a $1\frac{1}{2}$ inch right-angled bend.
6. At $1\frac{1}{2}$ inches depth. Soil water content on the 15th day of each month. The method employed was similar to that already described (Nash 1939, p. 261).

Results are expressed as a percentage of dry weight. Maximum and minimum temperature readings were taken every other day, and evaporation once a week. The mean temperatures referred to subsequently are approximations, being the average of the mean monthly maximum and minimum readings.

Evidence of the Shifting of the Breeding-ground.

Pupal Density.

As is the case with all residual forest islands, no breeding takes place in Taylor's island during the heavy rains (July–September); this is probably due to the very sodden conditions and high soil water content (Nash 1939). In October or November *G. tachinoides* starts breeding in the forest fringe, but *G. morsitans* does not usually start here until December. The puparial returns for the dry season are given in Table I for both species over a period of three years.

Reference to the upper half of the table shows that every year there is a sudden decrease in the pupal density of *G. morsitans* in the forest edge in March, and that it corresponds with a great increase in the centre of the forest. By April the evacuation of the edge of the forest is complete and pupal density within the forest is maximal.

The lower half of the table gives the same data for *G. tachinoides*. The movement across starts in February, but the rate of decrease in pupal density is much greater in March. Pupal density does not increase in the centre of the forest as much as might be expected, because the bulk of this species' breeding shifts to the adjacent river-bed site, where the evaporation and temperature are lower than anywhere else (Nash 1939).

Clearly the period to be investigated extends from February to April, March being the critical month.

TABLE I.

To show the Annual Shifting of Breeding from the Edge of the Forest to the Centre.

	No. 1—Forest Edge			No. 2—Centre of Forest		
	1938-39	1939-40	1940-41	1938-39	1939-40	1940-41
<i>Morsitans</i>						
October ...	2	0	?	0	0	0
November ...	0	8	?	0	0	0
December ...	6	47	30	0	0	0
January ...	4	55	27	2	0	0
February ...	20	133	82	44	7	2
March ...	4	39	22	97	67	81
April ...	0	2	2	131	118	148
May... ..	0	1	0	57	91	21
<i>Tachinoides</i>						
October ...	172	0	?	0	0	0
November ...	706	1,063	?	0	1	0
December ...	726	1,310	489	0	6	0
January ...	756	1,074	320	52	55	12
February ...	188	451	187	205	84	67
March ...	6	29	14	230	57	143
April ...	4	4	1	113	26	12
May... ..	0	3	1	8	56	41

Pupal Mortality during the Shifting of the Breeding-ground.

The data for the last two seasons only are given in Table II. Unfortunately during 1939 the puparia from the two sites were not buried separately, as at that time this investigation had not been decided upon.

In February the pupal mortality in the edge of the forest is very low for both species. In March it increases greatly, *G. tachinoides* being more seriously affected. In April there hardly are any puparia, but the few there are mostly succumb. The number of puparia found at this critical period is bound to be small, but the writer is convinced that the high mortality is no chance result, as he has observed it so frequently when other breeding-grounds are being evacuated.

TABLE II.

To show the increased Pupal Mortality associated with the Evacuation of a Breeding-ground.

		No. 1—Forest Edge				No. 2—Centre of Forest			
		1940		1941		1940		1941	
		No. of puparia	Mort. %	No. of puparia	Mort. %	No. of puparia	Mort. %	No. of puparia	Mort. %
<i>Morsitans</i>									
February	...	133	8	82	4	7	14	2	0
March	...	39	28	22	32	67	12	81	15
April	...	2	100	2	50	118	19	148	9
<i>Tachinoides</i>									
February	...	451	17	187	10	84	17	67	33
March	...	29	79	14	79	57	14	143	17
April	...	4	100	1	100	26	31	127	27

The puparia found in the centre of the forest in March were perfectly healthy, but by April even the middle of the forest island was possibly becoming rather unfavourable for *G. tachinoides* puparia. The high mortality of 33 per cent. for this species in February 1941 cannot be explained.

The Stage in Pupal Life at which Death occurred.

All dead puparia were dissected and the percentage which contained fully-developed tsetse is given in Table III. As the number of dead puparia was small, and since the same trend was observed in each year, the data for 1939-40 and 1940-41 have been combined.

TABLE III.

The Percentage of Dead Puparia which contained fully developed Tsetse.

		No. 1—Forest Edge				No. 2—Centre of Forest			
		<i>G. morsitans</i>		<i>G. tachinoides</i>		<i>G. morsitans</i>		<i>G. tachinoides</i>	
		Total dead puparia	Died late in life %	Total dead puparia	Died late in life %	Total dead puparia	Died late in life %	Total dead puparia	Died late in life %
November	...	1	—	34	29	—	—	—	—
December	...	16	31	56	23	—	—	2	—
January	...	11	27	55	30	—	—	22	36
February	...	13	54	37	39	1	—	36	19
March	...	18	61	18	53	20	20	32	34
April	...	2	—	—	—	36	31	42	38

From November to January the percentage of dead puparia in the forest edge which had died late in pupal life ranged from 20 to 30 per cent., but by March the range had risen to from 50 to 60 per cent. No similar rise occurred in the centre of the forest. Admittedly the numbers are small, but much confirmatory evidence is available from other breeding-grounds, which shows that at the time of evacuation the increased pupal mortality is invariably associated with a marked increase in the percentage of dead puparia which contain fully-formed adults. This is particularly interesting because it is opposed to the general trend, which is for puparia to die early in pupal life in the dry season, but late in life in the rains (Nash 1939, p. 281).

Conclusions.

1. *G. tachinoides* starts shifting its breeding-ground from the edge of the forest to the centre in February, but *G. morsitans* waits until March. By the end of March the evacuation is complete.

2. The last puparia to be deposited in the edge of the forest during March suffer an increased mortality; the effect is much more pronounced with *G. tachinoides* puparia. No such increased pupal mortality occurs in the centre of the forest.

3. An abnormally large percentage of the puparia which die in the edge of the forest in March contain fully developed tsetse, whereas the percentage remains low in the centre of the forest.

The Climate in the Adult Environment.

The climatic conditions vacated by the fly in the edge of the forest will now be compared with those in the centre, so as to ascertain what the female gains by this annual shifting of the breeding-ground.

Meteorological data have been collected for 18 months, but to economise in space only the data for the critical months of the last two years will be given.

Temperature.

Minimum temperature data have been omitted as they cannot be relevant; the lowest temperatures occur in December and January, but by the time the evacuation takes place the mean monthly minimum temperature has risen some 10°F. above the January figure.

In the following tables data for the two sites are presented side by side for each season. "E" stands for Edge of Forest and "C" for Centre of Forest.

TABLE IV.

Mean, Mean Maximum, and Absolute Shade Temperatures at Four Feet, and Mean Maximum and Absolute Shade Temperatures on Surface (°F.).

	At 4 feet above soil surface												On surface			
	Mean temp.				Mean max.				Absolute max.				Mean max.		Absolute max.	
	1940		1941		1940		1941		1940		1941		1940		1941	
	E	C	E	C	E	C	E	C	E	C	E	C	E	C	E	C
Jan.	69.2	67.8	71.4	69.2	90.1	88.0	89.1	86.2	95.0	93.5	97.0	92.5	87.2	82.6	93.5	89.6
Feb.	71.4	70.2	73.2	71.4	90.9	89.7	90.3	88.6	96.0	95.0	100.0	97.5	88.2	88.3	95.0	92.0
March	76.8	75.5	82.8	80.8	96.0	95.2	97.7	95.7	103.5	103.0	104.0	102.5	96.5	92.3	102.0	97.0
April	84.6	83.6	90.0	88.9	102.0	100.9	101.4	100.0	105.5	105.0	104.0	103.5	99.8	96.8	102.0	99.0
May	87.6	87.3	85.8	84.8	102.0	101.1	93.7	92.6	107.5	105.5	103.0	102.0	93.5	90.9	103.0	98.5

Mean Temperature and Mean Maximum Temperature at 4 feet :—Both these factors can be ignored as there is only a difference of 1.2°F. between the two sites.

Absolute Maximum Temperature at 4 feet :—Again the difference is very slight, but it should be noted that readings from both sites lie in the critical zone. The writer found that when batches of tsetse were caged in the hot weather, all the *G. tachinoides* would succumb if the day temperature reached 105.5°F., and all the *G. morsitans* if it reached 106°F.; the critical zone for *G. tachinoides* was 102°–105.5°F. and for *G. morsitans* 102.5°–106°F. (Nash 1935, p. 110). Since it has been found that on very hot afternoons the fly takes advantage of the cooler conditions at ground-level, this factor can be ignored.

Mean Maximum Temperature on Soil Surface :—The difference is appreciable, the centre of the forest being 3.4°F. cooler. Unfortunately readings are only available for one year, as during 1939–40 the thermometer used in no. 2 site failed to hold its maximum readings and there was no spare instrument.

Absolute Maximum Temperature on Soil Surface :—This is a very important factor. Temperatures in the forest edge reached the lower limits of the critical zone, but in the centre of the forest there was a distinct margin of safety, the temperature never rising above 99°F.

* * * * *

By shifting into the centre of the forest island the adult female did not obtain appreciably better temperature conditions at four feet above the ground, but she did assure for herself a sanctuary on the ground where she could avoid the lethal effect of high temperature on very hot afternoons.

Evaporation.

The average daily evaporation for each month is given in Table V. The difference between the evaporation of the edge and that of the centre of the forest island is shown as E-C. The results are expressed as cubic centimetres of water evaporated per day.

TABLE V.

Mean Daily Evaporation at 4 Feet and at 5 Inches above the Soil Surface (cc.).

	Evaporation at 4 feet						Evaporation at 5 inches.					
	1940			1941			1940			1941		
	E	C	E-C	E	C	E-C	E	C	E-C	E	C	E-C
January	40	25	15	42	26	16	32	20	12	35	20	15
February	53	32	21	51	33	18	42	26	16	42	27	15
March	63	42	21	60	42	18	52	33	19	50	34	16
April	60	49	11	46	38	8	51	34	17	38	29	9
May	39	32	7	25	23	2	33	26	7	19	16	3

Evaporation at 4 feet and 5 inches :—Here again are two very important factors, since at both heights above the surface the evaporation for March is very considerably less in the centre of the forest than in the fringe.

* * * * *

Conclusions.

Out of the factors studied only two would seem to be of possible importance, *viz.* the absolute maximum temperature on the soil surface, and the evaporation rate between four feet and the ground-level. Since the former is of a very transitory nature and can be avoided by a temporary retreat into the centre of the forest during the hottest hours of the day, evaporation would appear to be the most important factor.

It is suggested that by moving into the centre of the forest, where the evaporative power of the air is much less, the female will gain because her rate of water loss will be reduced, and therefore she will be less susceptible to heat, even though the temperature is not very much lower (Jack 1939).

The Climate in the Adult Environment in relation to Adult Behaviour.

Jack & Williams (1937) found that the reaction of *G. morsitans* to light at medium temperatures is positive, but that if the temperature is raised sufficiently high, the reaction is reversed and becomes strongly negative, the flies seeking the dark. This reversal starts with the average fly at a temperature of about 90°F. (32°C.) and is accelerated as the temperature rises towards 104°F. (40°C.). Further, this negative reaction to light is so strong that flies will leave a high temperature in the light half of the apparatus for a much higher, lethal temperature in the dark half. They found that the fly's reaction to light is much stronger than its direct temperature selection, and also that low humidity, apparently through its effect in lowering the water-content, lowers the temperature at which the fly's negative reaction to light is manifested.

The conditions required to stimulate this negative reaction to light occurred in the forest edge in March. The average number of hours of daylight during which the shade temperature was above 90°F. has been worked out for the first four weeks of February and March 1941, using data from the thermohygraph charts.

The length of day at this season can be taken as 12 hours.

		1st week	2nd week	3rd week	4th week
February, 1941	...	1.0 hours	0.0 hours	5.4 hours	5.9 hours
March, 1941	...	3.9 hours	8.9 hours	9.7 hours	8.5 hours

During the first half of February the temperature rarely reached 90°F., but during the last part of the month it was above this figure for nearly half the hours of daylight. By the third week in March there were only just over two hours a day during which the female would not be influenced by her negative reaction to light to extrude her larva in the darkest parts of the centre of the forest. Even these few hours invariably occur early in the morning and under laboratory conditions female tsetse tend to larviposit in the late afternoons or during the night (Potts 1933).^{*} The fact that the centre of the forest is hardly any cooler than the edge is immaterial, since Jack & Williams have shown that the negative reaction to light is so strong that the tsetse would enter a darker place even though it were hotter. The high evaporation in the forest edge would tend to lower the temperature at which the negative reaction starts. Should *G. tachinoides* react at a lower temperature than *G. morsitans*, this would account for the fact that this species starts shifting in February.

^{*} Since writing the above, a small experiment using six pregnant females of each species resulted in all the larvae being extruded during the afternoon or night.

Observation confirms that during the hottest hours of the day the fly are inactive in the centre of the forest, but in the evening, when the temperature ranges from 90°–100°F., there is no doubt that the stimulus of hunger overcomes the negative reaction to light as tsetse attack in the forest edge at this time. However, since Jack (1939) has shown with *G. morsitans*, and Helen Mellanby (1937) with *G. palpalis*, that the female does not tend to feed during the last few days before extruding her larva, the counter-stimulus of hunger is unlikely to occur at the time of parturition.

Conclusions.

By March the diurnal temperature in the forest edge has risen so considerably that it is usually above the point at which *G. morsitans* starts to develop a negative reaction to light. This should cause the adults to seek the darkest thickets in the centre of the forest island, and would account for the cessation of breeding in the more brilliantly illuminated forest edge (Plate VI, figs. 1, 2).

The Climate in the Pupal Environment.

Temperature at 1½ inches Depth.

Since the data for the two years are very similar, only the figures for 1940–41 are given in Table VI.

TABLE VI.
Temperature at 1½ inches Depth (°F. 1940–41).

	Mean temp.		Mean max.		Absolute maximum		Mean minimum		Absolute minimum	
	E	C	E	C	E	C	E	C	E	C
December	69.1	65.5	76.3	71.3	78.8	72.5	61.8	59.6	60.8	58.7
January	70.9	65.7	79.9	72.1	81.5	75.2	61.8	59.3	58.3	56.2
February	72.1	67.7	80.9	73.9	86.0	78.8	63.3	61.5	61.2	58.3
March	79.7	75.1	87.7	81.3	93.2	86.0	71.7	68.8	65.7	63.2
April	84.5	82.2	90.3	86.5	94.2	87.8	78.7	77.8	76.2	72.9
May	83.0	81.4	89.2	85.1	96.8	89.6	76.7	77.7	74.3	74.7

Mean Temperature: The mean soil temperature is rather cooler in the centre of the forest, being 4.5°F. less in March. The mean March temperature in the edge of the forest was 76.8°F. (25°C.) in 1940, and 79.7°F. (26.5°C.) in 1941. Such temperatures could not have caused a 79 per cent. mortality among *G. tachinoides* puparia, since Buxton & Lewis (1934) found that even at 86°F. (30°C.) and a R.H. of 65 per cent. they only got a 35 per cent. mortality with puparia of this species, and a 21 per cent. mortality with *G. morsitans*.

Absolute Maximum Temperature: The highest soil temperature recorded in the forest edge for March was 93.2°F. (34°C.) but this is far below the thermal death point, which according to Buxton & Lewis (1934) ranges from 107.6–113°F. (42–45°C.) depending upon the age and species of the puparia.

Absolute Minimum Temperature: The lowest soil temperature recorded in the forest edge for March was 65.7°F., whereas puparia can survive 32°F. for 24 hours.

The temperature conditions at 1½ inches depth in the pupal environment of the forest edge could not have been responsible for the increased pupal mortality of March.

Soil Water Content at 1½ inches Depth.

TABLE VII.
Soil Water Content at 1½ inches Depth, expressed as a Percentage of Dry Weight.

	1940		1941	
	E	C	E	C
January ...	3.9	6.5	3.1	5.7
February ...	2.5	4.5	3.1	4.1
March ...	2.3	3.4	2.6	4.0
April ...	2.3	3.0	8.5	6.4
May... ...	2.5	2.9	21.7	8.1

In 1940 the rains were very late and the soil water content remained low until the end of May, but in 1941 there was 0.25 inches of rainfall on 8th April, after which the soil water content rose. The soil water content is always higher inside the centre of the forest until the first rain falls.

Buxton (1936) published a curve showing the humidity of the soil atmosphere in relation to the water content. His "thicket" soil was taken from 12 sites, chosen at random, in Taylor's forest island. He showed that if the water content of the soil from this island was over 4 per cent. the soil atmosphere would be saturated, or very nearly saturated. It will be seen from Table VII that the soil atmosphere in the forest edge must be considerably below saturation for some months, and that even in the centre of the forest the air is not always saturated.

Buxton's experiment was carried out at a temperature of 73.4°F. (23°C.), so that when the mean monthly temperature at 1½ inches depth was close to that figure we can get some idea of the probable relative humidity of the soil atmosphere by reading off our soil water content figures against his curve.

If this is done we get the following results which suggest that it is unlikely that atmospheric humidity of the soil fell much below 60 per cent.

Site	Month	Mean temp.	Soil water content %	Approximate atmospheric humidity of soil %
Edge	January, 1940 ...	71°F.	3.9	92
Edge	February, 1940 ...	72°F.	2.5	63
Edge	March, 1940 ...	77°F.	2.3	60
Edge	January, 1941 ...	71°F.	3.1	80
Edge	February, 1941 ...	72°F.	3.1	80
Centre	March, 1941 ...	75°F.	4.0	93

Buxton & Lewis (1934, p. 214) found that with 65 *G. tachinoides* puparia kept at 75°F. (24°C.) and R.H. 65 per cent. the pupal mortality was only 21 per cent. If low humidity was to cause a 79 per cent. mortality, such as occurred in the forest edge

in March, one would expect from Buxton & Lewis's table (p. 214) that a R.H. below 19 per cent. at a temperature of 86°F. would be required. The evidence produced, though admittedly unsatisfactory, does not suggest that such conditions ever occurred.

Discussion on the Climate of the Pupal Environment in relation to Pupal Mortality

The evidence available suggests that the March climate of the pupal environment at 1½ inches depth in the forest edge is not sufficiently severe to explain the high pupal mortality which occurs during the last month in which the breeding-ground is used. This did not surprise the writer, as in the years prior to this detailed investigation all the puparia found throughout Taylor's forest island were always buried at site no. 1, in the forest edge; yet mortality amongst them was never very high. For example, the following are the figures for *G. tachinoides* puparia in the March of three years:—

March 1937	Total puparia = 519	Mortality per cent. = 20 per cent.
" 1938	" " = 617	" " = 22 "
" 1939	" " = 230	" " = 22 "

In those days the puparia searchers, knowing that the bulk of the breeding had shifted, did not waste time in the edge of the forest but concentrated on the dense thickets in the centre; thus the pupal mortality figures just given refer to puparia that had originated in the centre of the forest.

Hence puparia from larvae extruded in the centre of the forest island in March suffer no excessive mortality if buried in the forest edge, but puparia from larvae which have been extruded in the forest edge show a high mortality.

This would suggest that the adverse factor in the forest fringe must act early in pupal life; but this is not so, as it was shown on p. 331 that an abnormally large number of the dead puparia contained fully-formed adults. Such puparia suggest that difficulty was experienced in hatching. But the adverse factor could not have operated at this late stage, or we should have found that the puparia from the centre of the forest also tended to die very late in life if buried in the forest edge; actually the bulk of them died early in life, which is normal for all breeding-grounds in the dry season, except those that are just being vacated. Hence the adverse factor could not have operated early, or late, in pupal life—but it might have acted before the completion of pupation. It is quite possible that under the conditions described, of very high surface evaporation and in soil in which the atmosphere is not saturated, that the slimy secretion covering the larva may dry up too rapidly, or that the pupal integument may harden too quickly, thus upsetting its mechanical structure and preventing the adult from pushing off the pupal cap. If this was the correct explanation, it would account for the fact that only puparia from larvae extruded in the forest edge show a high pupal mortality. Unfortunately nothing is known about this obviously critical pre-pupation period. It would be interesting to ascertain whether pupation under conditions of abnormally high saturation deficit adversely affects the subsequent hatching. The tendency for dead puparia in the rains to contain fully-developed adults may be due to the mechanical difficulty of pushing off the pupal cap in heavy, sodden soil. It would not be a common occurrence, as pupal mortality is exceptionally low in this season (Nash 1937).

There is yet another possible explanation:—It has been shown that conditions at 1½ inches cannot be harmful, but supposing the bulk of the puparia pupate nearer the surface, then they would experience more adverse conditions than those recorded. But since the mean surface maximum temperature was only 93.4°F. and 96.5°F. for the March of each year, it seems highly improbable that puparia at say ¾ inch depth would be subjected to dangerously high temperatures: however, atmospheric humidity may be much lower nearer the surface. But if it were true that the puparia were already dead when found, having been killed by severer conditions nearer the soil surface, one would expect to find that most of them had died early in pupal life, not late.

Conclusions.

1. The climate of the pupal environment at 1½ inches depth in the forest edge is not inimical to survival.
2. The high pupal mortality among the March puparia of the forest edge *must* take place before the puparia are formed.
3. The reason for this mortality is obscure, but since death does not tend to occur early in pupal life, but late, it is suggested that the high surface evaporation and unsaturated soil atmosphere may adversely affect the formation of pupal integument at the time of pupation, rendering it impossible for many of the adult flies to emerge.

General Summary.

It has been shown that *G. morsitans* and *G. tachinoides* annually shift their breeding-ground in March from the edge of a residual forest island to the centre—a distance of some 40 yards. The move is associated with an increase in mortality amongst the last puparia to be found, death usually having occurred late in pupal life.

The object of the investigation has been to discover what prompts the female to move just before pupal mortality increases.

It has been found that there is little difference in the temperature conditions of the two breeding-grounds, but that the evaporation rate is one-third less in the centre of the forest. However, the abandonment of the forest margin is not explained by attributing to the female the ability to detect differences in the evaporative power of the air, but rather by the negative reaction to light developed by the whole community under conditions of universally high temperature. The period of migration coincides with an abrupt increase in the number of hours when the shade temperature is above 90°F. (32°C.), the temperature at which Jack & Williams found that the negative reaction to light begins. During March the diurnal temperature is below this figure only immediately after dawn, when under laboratory conditions parturition rarely occurs. Since the temperature remains above 90°F. until well after activity has ceased at dusk, it is probable that at any rate the non-hungry tsetse spends most of the day and all the night in the centre of the forest. In the evenings field observations suggest that the stimulus of hunger may overcome the negative reaction to light, as then flies will undoubtedly attack in the forest edge, but since pregnant females rarely feed for several days before parturition, this counter-stimulus is unlikely to be operative at the time the female extrudes her larva.

By moving into the centre of the forest the adults will gain a reduction in temperature of only 3 or 4°F., but they will be less susceptible to heat, as the much lower evaporation rate will reduce their water loss.

The climatic conditions in the pupal environment of the forest edge at 1½ inches depth were found to favour survival, so it was concluded that the factor which inhibited emergence must have been operative before the puparia were formed. Possibly high surface evaporation and unsaturated soil atmosphere affect the formation of the pupal integument at the time of pupation, rendering subsequent emergence impossible.

The meteorological data collected in this investigation are more detailed and localised than anything yet published by the writer, and should give a better picture of the dry season adult and pupal environments in a locality which is very close to the hot, dry limits of the range of both species.

Puparia are found in large numbers in soils whose mean monthly temperatures range from 69°–82°F. (20·6–27·8°C). Field observations suggest that a constant

temperature of 72°F. (22°C.) with a R.H. of 80 per cent., or 77°F. (25°C.) at R.H. 100 per cent., are conditions which should provide very healthy puparia if reproduced in the laboratory (see Appendix).

By way of conclusion, the writer is grateful to Dr. H. M. O. Lester, O.B.E., Deputy Director, Nigerian Sleeping Sickness Service, for facilitating the investigation. Mention must be made of the complete reliability shown by Mallam Ibrahim who has been directly in charge of the routine observations.

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APPENDIX.

Temperature Conditions in the Pupal Environment which may be of interest to Laboratory Workers.

It is believed that hitherto data have never been published which gave the mean temperature of the pupal environment under natural conditions; hence the figures in Table VI of this paper are of particular interest. They cover the dry season and early rains, and include the coldest and hottest months of the year.

Puparia were found in large numbers under conditions ranging from :—

Mean monthly Temperatures 1½ inches Depth.

Mean Range.

69.1–82.2°F. (20.6–27.9°C.).

61.8°–86.5°F (16.5–30.3°C.).

Puparia of both *G. morsitans* and *G. tachinoides* were particularly healthy in February 1941, when the mean temperature was 72 F. (22.2°C.) and the mean range 63.3–80.9°F. (17.4–27.2°C.).

During the rains the residual forest islands are abandoned and breeding takes place in the driest sites in the open woodland, e.g. under logs and palm-fronds. The pupal mortality is exceptionally low in these sites, owing, it is believed, to the relative dryness of their soils. Even though pupal mortality appears to be related to the absolute soil water content and not to temperature (Nash 1939), it is worth recording that the mean soil temperature in the heavy rains is very constant and fluctuates between 76 and 78°F. (24.4–25.6°C.), with a mean range of 73–82 F. (22.8–27.8°C.).

Field observations suggest that the following would provide very healthy conditions for the puparia of *G. morsitans* and *G. tachinoides* kept under laboratory conditions :—

The temperature constant at 72°F. (22°C.) with a relative humidity of 80 per cent.

The temperature constant at 77°F. (25°C.) with a relative humidity of 100 per cent.

EXPLANATION OF PLATE VI.

- Fig. 1.—Site no. 1. The forest edge looking inwards towards the centre of the residual forest island.
- Fig. 2.—Site no. 1. The forest edge looking outwards. *N.B.*—Brilliant illumination in adjacent woodland.
- Fig. 3.—The screen used for obtaining the shade temperature on the soil surface. The atmometer measuring evaporation at five inches is shown on the right. Site no. 1.



Fig. 1.



Fig. 2.



Fig. 3.

ON THE ECOLOGY OF LARVAE OF *ANOPHELES CULICIFACIES* GILES. IN BORROW-PITS.*

By PAUL F. RUSSELL and T. RAMACHANDRA RAO.

(PLATE VII.)

Introduction.

This paper reports some chemical, planktonic, and seasonal observations, in seepage-filled borrow-pits in Pattukkottai Taluk, Tanjore District, Madras, over a period of three years, on the ecology of larvae of *Anopheles culicifacies*, Giles.

Previous papers bearing on this subject are those by Russell, Menon & T. R. Rao (1938), Russell (1938), and Russell & T. R. Rao (1940, 1941). Among other conclusions, these papers noted that *A. culicifacies* was the chief vector of malaria in the area, that borrow-pits filled with irrigation water by seepage were a prolific source of this species, that about 11 per cent. of all *culicifacies* larvae collected came from borrow-pits, that 68 per cent. of all collections in borrow-pits contained this species, and that 46 per cent. of all larvae taken in borrow-pits were of this species, and finally, that although *culicifacies* larvae were found throughout the year, there were seasonal trends. The curves of incidence and density rose rapidly from the onset of the irrigation season in mid-June to peaks in August or September, with a decline in both incidence and density in October and November to moderate levels in December and January and very low levels from February to June, when no irrigation water entered the area.

Two Problems.

The papers cited above suggested two problems for further study: (1) what factors brought about the marked decline in intensity of breeding of this species from September to January, during the second half of the irrigation season; (2) what factors made newly filled borrow-pits, in comparison with other types of habitat, attractive to *A. culicifacies*. Only the first question will be dealt with in detail in this paper. The second will be considered fully in later reports. The extensive literature on the subject of ecology of Anopheline larvae will also be discussed in relation to our studies in later reports.

Methods.

These studies were made for the most part in borrow-pits dug by ourselves for experimental use. In all cases the pits filled by irrigation water seeping from canals near by. Collections of larvae were standardized by measured time of collecting.

The following chemical tests were made throughout the study by ourselves immediately after taking water samples:

- (1) pH and residual pH, by Hellige comparator.
- (2) Dissolved oxygen in cc. per litre by Winkler's process.
- (3) Free CO₂, phenolphthalein and methyl orange alkalinities in parts per 100,000.

* These studies were conducted under the auspices and with the support of the International Health Division of the Rockefeller Foundation, co-operating with the Health Department of Madras Province, with the King Institute of Preventive Medicine, Gundy, until December 1939, and with the Pasteur Institute of Southern India, Coonoor, in 1940-1941. The authors are grateful to Rao Sahib T. N. S. Raghavachari, B.A., Senior Public Health Assistant at the King Institute, Guindy, for his chemical analyses of water samples.

During 1938 and 1939 the following additional tests were made for us at the King Institute, Guindy, generally one or two days after collection of samples :

- (a) Qualitative tests for nitrates, nitrites, sulphates, iron, and poisonous metals.
- (b) Quantitative tests for turbidity ; temporary, permanent, and total hardness ; chlorine ; ammoniacal and albuminoid nitrogen ; and oxygen absorbed.

At the time of collection visual observations were made as regards macroscopic flora, such as floating, vertical, and submerged vegetation, green and blue-green algae. Macroscopic parasites or predators were also noted, if present.

Soon after collection the plankton was studied microscopically, with special reference to green and blue-green algae, diatoms, protozoans, rotifers, copepods, amorphous matter, and total plankton. In plankton examination, an attempt was made to keep quantitative records. In 1938-1939, we used an ordinary hand centrifuge for concentrating the sample, but in 1939-1940 and 1940-41, we used the more precise Sedgwick-Rafter funnel method.

The procedure used in the centrifuge method was as follows : 15 cc. of the sample were centrifuged for five minutes, and the supernatant fluid was poured off until a residue of about 0.2 cc. was left. Then the concentrate was well shaken, transferred to an ordinary slide, and covered with a cover glass, 20 mm. \times 40 mm. in size. Fifty fields were examined with the high power of the microscope and the number of organisms of each kind was enumerated. Amorphous matter and some of the larger forms, especially Copepoda, Rotifera, etc., were not enumerated. Therefore the final result was not accurate quantitatively but was quite suitable for qualitative observations, and it provided a rough guide to fluctuations in the several types of organisms.

With the Sedgwick-Rafter funnel, we used the technique described in detail by Whipple (1927). In most cases, 500 cc. of the sample were employed and the final concentration was to 5 cc. We used the Whipple disc and the 1 cc. Whipple counting cell, and examined 10 fields with a 10 \times ocular and 8 \times objective, recording counts on a special mimeographed form. Each organism was finally enumerated by volume, *i.e.* in standard cubic units per cc. of sample. Whipple has fully discussed these methods and the sources of error. The records provide a fair measure of the quantitative fluctuations in plankton organisms.

We have not attempted to identify planktonic forms by species, a procedure that only a competent systematic algologist or protozoologist could adopt. We were able, however, to determine most of the common genera. In several cases, especially among Copepoda, Rotifera, and flagellate Protozoa, we were unable to do this, and hence we have in all such cases merely recorded the forms as copepods, undetermined flagellates, undetermined filamentous blue-green algae, etc. In this paper we do not propose to discuss the fluctuations of each form, but shall discuss the fluctuations of each class taken together.

Seasonal Variations in Intensity of Breeding of *A. culicifacies* in Borrow-pits.

As noted above, other reports have made it clear that the density of *A. culicifacies* larvae in borrow-pits, as well as other places, in this area reaches a peak in August or September and then declines as the irrigation season advances from September onwards. This is borne out, as shown in Table I, by collections in one of the pits observed in these studies.

But that this decline is not to be explained simply as an effect of season became apparent in 1939 when we made collections in two experimental pits, nos. 3 and 4, which were similar and side by side, the first having been excavated on 30th July and the second on 19th September. As shown in Table II, the usual decline had become well marked by early September in pit no. 3, but when the new pit no. 4 filled with fresh water on the 19th it was attractive to *culicifacies*, regardless of season, and the decline began in October.

TABLE I.
A. culicifacies Larvae collected in Borrow-pit No. 1.

Date	Larvae collected	Date	Larvae collected	Date	Larvae collected
1938 June 29	28	1938 Sept. 12	7	1938 Nov. 30	0
July 4	24	21	19	Dec. 7	0
11	24	29	7	15	4
20	39	Oct. 4	8	21	11
25	24	11	1	1939 Jan. 1	2
Aug. 1	92	18	12	5	2
8	67	24	6	12	1
15	127	Nov. 1	2	17	0
24	154	8	8	25	49
29	63	16	0	31	0
Sept. 5	128	22	8		

TABLE II.
A. culicifacies Larvae collected in Borrow-pits Nos. 3 and 4.

Date	Larvae collected		Date	Larvae collected	
	Pit 3	Pit 4		Pit 3	Pit 4
1939 Aug. 3	101	—	1939 Nov. 2	6	9
10	93	—	8	0	0
16	211	—	17	14	11
22	108	—	22	8	15
30	95	—	Dec. 1	Dry	11
Sept. 7	21	—	8	Dry	Dry
13	0	—	15	3	0
19	4	—	21	4	5
25	7	128	29	4	0
Oct. 5	9	29	1940 Jan. 13	8	0
12	21	63	20	0	42
18	7	35	27	6	7
27	2	4	Feb. 2	16	2

TABLE III.
Collection of A. culicifacies Larvae in a Series of Borrow-pits excavated in Pairs at monthly Intervals.
Collections made twice a Month in all existing Pits.

Month and time of collection	Month pit was excavated and pit numbers																										
	May 1940			June			July			August			September			October			November			December			January 1941		
	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19									
1940—																											
June	b	249	N.C.	N.C.	176																						
July	a	296	842	327	182																						
	b	462	218	147	9	68	101																				
August	a	114	67	101	42	18	60																				
	b	0	60	22	62	36	0	165	188																		
September	a	0	29	10	5	29	44	28	61																		
	b	10	85	14	3	32	14	20	19	111	210																
October	a	23	71	5	0	43	3	39	21	10	58																
	b	0	5	0	0	0	0	9	1	3	0	16	43														
November	a	27	27	11	3	6	13	4	21	11	10	3	18														
	b	22	0	31	0	0	9	7	6	6	17	44	4	15	64												
December	a	0	0	0	0	0	0	0	2	3	7	12	2	4	13												
	b	0	0	0	0	0	0	0	0	0	0	0	0	0	19	0	0										
1940—																											
January	a	0	0	0	0	0	0	0	0	0	0	0	0	0	31	5	7										
	b	0	0	0	0	0	0	0	0	0	3	0	0	0	0	18	21	0	0								

Notes: a—collection first half of month. b—collection second half of month. N.C.—No collection.

Therefore, in 1940, we dug a special series of 18 borrow-pits, each 9 × 3 feet and 2½ feet deep, on rented land adjacent to a canal (Plate VII, fig. 2). Two were dug usually about the 20th of each month from May to January inclusive. The irrigation water came on 15th May instead of 15th June as usual. The water was turned off early in January, so that only one collection was made in the January pits before they became dry. Rain-water occasionally fell into the pits, but bunds kept the surface flow out so that, for the most part, the water in the pits was seepage from the canal. Pits dug in the same month were not side by side but were some distance apart. Collections were made in each existing pit twice each month, and are tabulated in Table III.

It was interesting to note that in each pit, regardless of season, the highest numbers of *culicifacies* larvae were present when the pit was young, and there was always a decline as the water in the pit stood longer, that is, as the pit became older. Again, at any given time, the greatest density of *culicifacies* larvae was in the newest pits. Finally, although the highest numbers of larvae were always in the newest pits, the level of these highest numbers from October onward declined markedly (see Table III).

Discussion of Seasonal Variations.

If in Table III one line be drawn so that it passes through the largest collection made in each pit for the entire period, and another line be drawn so that it passes through the largest collection in the second half of each month from among all the pits, these two lines will be found to cling fairly closely to the hypotenuse of the triangular table, *i.e.* the two lines are closely associated with the youngest pits. The zeros in the table are consistently in the oldest pits.

It is obvious that our first positive findings are (1) *culicifacies* larvae at any given season are more dense in new than in old borrow-pits; (2) the curve of density of *culicifacies* larvae always declines as pits become older; (3) as the season advances after September, peaks of density in new pits decline to lower levels.

These findings offer important clues as to the factors responsible for the decline in density of *culicifacies* larvae. It would appear that the decrease in numbers of larvae in individual pits from June to September was associated with an "ageing" of the pits rather than with season, that is, with internal rather than with external factors. On the other hand, the marked decline in numbers of larvae found in fresh pits from October to January appears to have been due, in part at least, to external factors, such as seasonal influences. The internal factor is discussed in part two of our observations, given below.

Not much need be said here about the external factor, which appeared to be so largely climatic, and which was discussed by the authors in another paper (Russell & T. R. Rao, 1941). Although, as noted in that report, there was some correlation between falling temperature and declining density of larvae after September, this relationship requires further study. The possibility that *culicifacies* might have a significantly lessened seasonal fecundity is not likely, in view of the following egg counts from wild-caught females (Table IV).

TABLE IV.

Average number of Eggs laid by wild-caught *A. culicifacies* at Different Seasons (1940-1941).

Season	Number of females	Average number of eggs laid
February-March ...	6	131
April-May ...	12	111
June-July ...	14	135
August-September	50	105
October-November	56	115
December-January	25	123

The effect of lowered temperatures in delaying development of the ova in the mosquito so as to increase the intervals between oviposition has not been studied. But it must be remembered that temperature variations in this area are not marked. For instance, mean temperatures in October are not more than 2°C. below those of July and August. November and December means are only about 3°C. below those in October. In no year under observation has the difference between the highest and lowest monthly mean temperatures been more than 6.3°C. The lowest monthly mean observed was 24.2°C., in December 1938, and the highest 30.5°C., in June 1937, May 1938, and June 1939. Mean relative humidities have never been below 60 per cent. They are always lowest from June to August and thereafter rise, until November or December, to highest means of about 82 per cent., gradually falling thereafter.

Further studies are in progress on the effect of temperature changes on *A. culicifacies*.

Variations in Physical, Chemical, and Biological Characters of Borrow-pits in relation to breeding of *A. culicifacies*.

In this section we shall report as briefly as possible observations of variations in certain ecological factors internal to some typical borrow-pits, and concurrent observations in the same pits on the density of *culicifacies* larvae.

Borrow-pit 1. (1938-1939).

The first pit we studied was excavated in 1938 just before the onset of the irrigation season. It was $19 \times 3 \times 1\frac{1}{2}$ feet in size, and was situated some 12 feet from a canal (Plate VII, fig. 1). As soon as water flowed in the canal, in mid-June, the pit began to fill by seepage and held water until about 1st February 1939. Weekly observations were made from 29th June, and, with a few exceptions, as shown in Table I, *culicifacies* larvae were always collected. *A. annularis*, *jamesi*, *hyrcanus* var. *nigerrimus*, *pallidus*, and *subpictus* larvae were also found in this pit, the last named species being common but somewhat less abundant than *culicifacies*.

It will be noted that intensity of breeding of *culicifacies* in pit 1 gradually and somewhat irregularly increased to a peak in August and the first week in September, thereafter declining suddenly and remaining at low levels, except for a final rise the last week in January.

As to physical conditions, we saw no correlation between density of breeding and depth of water, sheltering vegetation, turbidity, temperature of water, or rainfall. The temperature factor cannot be entirely ruled out and further studies are in progress.

As to chemical factors, we could find no significant correlations between fluctuations in larva density and variations in pH, CO₂, oxygen absorbed, dissolved oxygen, alkalinity, total solids, hardness of water, chlorine content, ammoniacal or albuminoid nitrogen. For lack of space, we cannot show the large table recording all these data but must be content to say that the pH ranged between 6.6 and 8.0, being most commonly 7.2 with a residual pH of about 7.8; CO₂ concentration was always below 1.4 parts per 100,000, generally about 0.8 parts; oxygen absorbed ranged between 0.065 and 0.540 parts per 100,000; dissolved oxygen varied from 3.8 cc. to 7.4 cc. per litre, generally between 4.5 and 6.5 cc., which is about the saturation point for the usual temperature encountered; total alkalinity was entirely due to bicarbonates, and rose from 2.4 parts to 12.6 parts per 100,000; total solids varied between 9 and 50 parts per 100,000; total hardness fluctuated between 1.5 and 5.0 parts per 100,000; chlorine ranged from 1.1 to 2.8 parts per 100,000; ammoniacal nitrogen from traces to 0.016 parts per 100,000; and albuminoid nitrogen from 0.007 to 0.045 parts per 100,000. Nitrates, nitrites, iron, and poisonous metals were not found, but there were occasionally traces of sulphates.

As to macroscopic fauna, no fishes were seen. Some tadpoles, *Notonecta*, *Gerris*, *Nepa*, larvae of mayflies and certain beetles, and nymphs of Odonata, were generally seen and doubtless destroyed some larvae. But we could see no correlation between the numbers of these predators and the density of *culicifacies* breeding.

Macroscopic flora was not abundant, and no floating or submerged higher vegetation was observed. There were scanty grasses on one side of the pit. Green algae were first seen in December, when *Chara* was observed as a scanty bottom growth. Occasional scanty masses of *Mougeotia*, *Spirogyra* and blue-green algae were also seen. *Aphanothece* and *Cylindrospermum* appeared in late August. In December and January, scanty masses of *Oscillatoria* and *Anabaena* were found. But the chief point to mention is that the increase and maintenance of blue-green algae coincided with the decrease in, and subsequent low density of, *culicifacies* larvae.

As regards plankton, the method of study used in 1938, as noted above, was not quantitatively accurate, so that no detailed results will be recorded here. But it may be noted even in the first examination, and from that time onwards, diatoms, green algae, and protozoa were observed in large numbers.

Blue-green algae first appeared on 20th July, but were scanty until 5th September, from which date onwards they were found continuously and in larger numbers. The number of species of these algae in the plankton was always low. The commonest forms were *Oscillatoria*, which had its peak in December, and *Cylindrospermum*, with its peak in October. The growth of *Cylindrospermum* from 5th September onwards coincided with the fall in density of *culicifacies*. On 30th November and 7th December, when good numbers of the same species were present, *culicifacies* larvae were entirely absent.

Protozoans were also comparatively more abundant during the latter part of the study at a time when *culicifacies* larvae were relatively few. In species they were richer than other groups, nine to ten species frequently being found together. Flagellates were always in greater numbers than ciliates. Some of the commonest forms were *Trachomonas* (a peak in November), *Peridinium*, *Mallomonas* (a sudden appearance and disappearance in November). Others less abundant but frequently found were *Euglena*, *Carteria*, *Halterium*, *Pandorina*, *Synura*, and *Anthophysa*. Once (on 16th November) when the water was turbid and almost yellowish in colour, a thin, brick-red scum had formed on the surface. No *culicifacies* larvae were found. The scum appeared to be due to abundant *Euglena* sp. (*Euglena haematoides*?) and strands of *Anabaena*. The brownish matter on the surface was also partly made up of masses of amorphous organic matter.

Diatoms were present in fair numbers, except for four consecutive weeks in July and August.

Green algae were more abundant than blue-green algae, but did not show any relation to *culicifacies* breeding. The commonest forms were *Staurastrum*, *Nephroclytium* (29th September), *Tetraspora* (29th September), *Closterium*, *Scenedesmus*, and *Coelastrum*.

By way of résumé, it may be noted that borrow-pit 1 seemed to be a favourable breeding-place for *culicifacies* from the time it filled with seepage water in June until the second week in September, when the density of larvae of this species suddenly became much lower, and remained so thereafter. Aside from climatic factors, mentioned above, the only ecological characters whose fluctuations seemed to be related to the variations in density of larvae were blue-green algae, both macroscopic and microscopic, and some microscopic Protozoa. In each case there appeared to be an inverse correlation. This finding, however inconclusive, made it of interest to continue the studies.

Borrow-pit 3 (1939-1940).

Borrow-pit 3 was excavated on 30th July 1939. It measured $9 \times 3 \times 2\frac{1}{2}$ feet and was located within about 12 feet of an irrigation canal. It quickly filled by seepage from the canal and held water until 16th November, when it became dry and remained so until 12th December, because no water was flowing in the canal owing to breaches higher up in the system. It refilled in December and finally became dry at the end of the irrigation season in February.

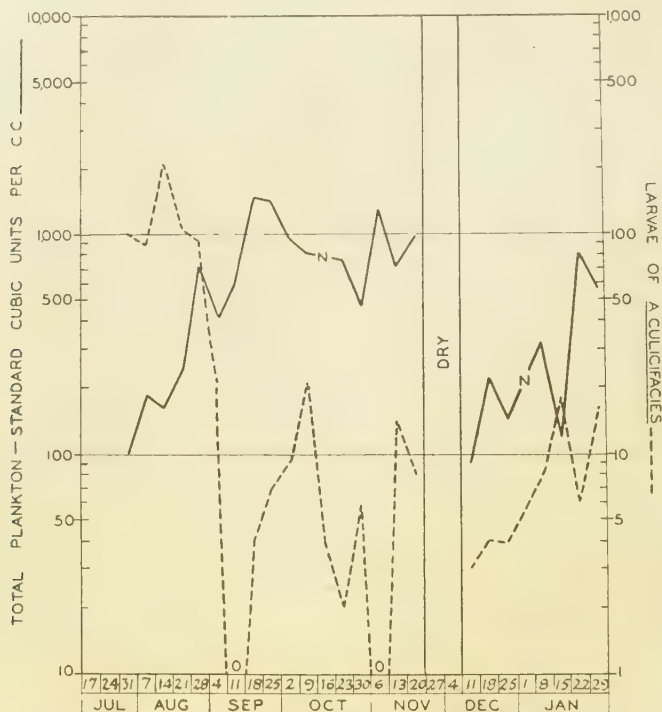


Fig. 1. Borrow-pit no. 3 (1939-1940) dug on 30th July 1939. Dates refer to weeks commencing with them. Note clear negative association between plankton and *culicifacies* larvae till November. Absence of such a correlation in December and January after the dry period has not been explained, but may be a result of interplay of other factors. N=No examination.

As shown in Table II and fig. 1, *culicifacies* larvae were usually present in this pit, having a peak of density in August, in the first weeks after excavation, and then declining rapidly and remaining at a relatively low level. *A. subpictus* larvae predominated after the decline of *culicifacies*. Minor species also found were *annularis*, *hyrcanus* var. *nigerrimus*, *pallidus*, and *vagus*.

Physical and chemical characters were observed as mentioned above in the description of methods, but none requires special comment and lack of space prevents showing the large table of recorded data. It must suffice to report that no significant relationship was noted between variations in density of *culicifacies* larvae and fluctuations in recorded physical or chemical characters.

As regards macroscopic fauna no fishes and only a very few insect predators were seen. The fact that the predators were not responsible for a decline in *culicifacies*

larvae was illustrated by the fact that on 2nd and 8th November, when predators were seen and when *culicifacies* density was low and nil, respectively, good numbers of *subpictus* larvae were present. It should also be noted that our observations indicated that the decline in *culicifacies* was due mainly to absence of, or to lessened, egg-laying.

Except for scanty grasses and some roots no macroscopic vegetation was present.

As regards plankton, the Sedgwick-Rafter funnel method was used and the quantity of plankton recorded in standard cubic units per cc.

On the first examination, plankton was scanty, consisting primarily of Protozoa (chiefly the stalked flagellate *Anthophysa*). Next to arrive were more protozoans, and gradually the plankton was built up to a fairly high density.

Cyanophyceae.—Some strands of *Oscillatoria* and *Anabaena* were first seen in the fourth week, but quickly disappeared. By 19th September they had reappeared in increased numbers. Finally they disappeared after the dry period in December. Blue-green algae were never abundant, but their appearance coincided with a reduction of *culicifacies*. But this does not explain why *culicifacies* did not thrive in December and January, when no blue-green algae were present.

Chlorophyceae.—Green algae made their first appearance the fifth week and established themselves fairly well. Chief forms were *Closterium* (peak—13th September), *Cosmarium* (peak—19th September), *Oedogonium* (peak—9th September), and an undetermined unicellular form. The appearance of green algae coincided with the decline of *culicifacies* density.

Diatoms.—After appearing in the second week (10th August) they occurred throughout the period until the end of January. No significant fluctuations were noticed.

Protozoa.—These formed the main portion of the plankton. They occurred especially abundantly on 19th September and on 13th January. On both these occasions, as well as most other weeks, the predominant protozoan was *Anthophysa*. This flagellate, having brownish red stalks, sometimes was abundant enough to give the surface of the water a brownish tinge, due to enormous numbers of dead stalks. Such a scum was formed on 18th and 27th October. Other common forms were an undetermined dinoflagellate, *Trachleomonas*, *Euglena* (two or three species), *Arcella*, *Diffugia*, *Phacus*, *Coleps*, and several undetermined flagellates. No significant relation to *culicifacies* breeding was observed.

Copepods and *Rotifers*.—These occurred throughout the period, with few exceptions. They appeared to have no significance.

Amorphous matter.—This was scanty at the beginning (75 standard cubic units per cc.) and gradually increased. From 11th September, onward, the totals were consistently higher than 500 until November. The increase in amorphous matter seemed to coincide with the decline in *culicifacies* density.

Total plankton.—From July to November there was a constant rise in total plankton, and this was also associated with decline of *culicifacies* density (see fig. 1). In December, immediately after the dry period, the total plankton was not high but gradually increased. This total plankton includes all living organisms and also the dead amorphous organic matter.

Résumé.—The factors which seemed to show some relationship to the decline in *culicifacies* density in this pit were planktonic forms of blue-green algae, green algae, amorphous matter, and total plankton.

Borrow-pit 4 (1939-1940).

Pit 4 was excavated on 19th September at a time when *culicifacies* density had definitely declined in pit 3 (see Table II). But, as usual, the density in the new pit

no. 4 was at first quite high, then declining in the typical manner (fig. 2). Pits 3 and 4 were similar in size and location, and in regard to fluctuations in physical and chemical characters. As in pit 3, so in 4, we saw no correlation between variations in density of *culicifacies* larvae and fluctuations in physical or chemical factors. The biological characters were very similar in their variations to those already described for pit 3, and increase in total plankton was associated with *culicifacies* decline (fig. 2).

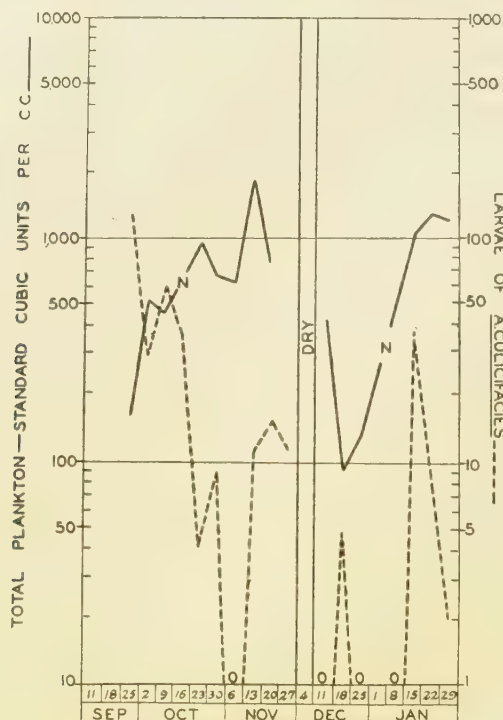


Fig. 2. Borrow-pit no. 4 (1939-1940) dug on 19th September, 1939. Comments as in fig. 1. Note abundance of *culicifacies* when pit was new. N=No examination.

Although space does not permit the complete table of all physical, chemical, and biological data as recorded week by week, we give in Table IV the complete data for the two pits on 25th September when pit 3 was almost two months and 4 only a week old. This table shows the following points of interest:—

- (1) The density of *culicifacies* was relatively high in the new pit and low in the older one.
- (2) The turbidity was 40 per 100,000 in the new and 10 parts in the older pit.
- (3) Albuminoid nitrogen was nearly 6 times greater in the older pit.
- (4) Other physical and chemical characters were not markedly different in the two pits.
- (5) Protozoa were about equally present but the newer pit had no green or blue-green algae.
- (6) The total plankton was nearly 9 times greater and amorphous matter was about 17 times greater in the old than in the newer pit.

TABLE V.

Ecological Conditions in Borrow-pits Nos. 3 and 4 on 25th September, 1939.

Description	Borrow-pit 3	Borrow-pit 4
Number of <i>culicifacies</i> larvae collected ...	7	128
Turbidity—visual	Clear	Slight
Peterson's turbidometer ...	10	40
Hydrogen ion concentration pH ...	6.8	7.2
Residual pH	8.0	8.0
Dissolved oxygen cc./litre at 31°C....	3.0	4.3
Carbon dioxide CO ₂ pts/100,000 ...	2.0	0.6
Phenolphthalein alkalinity " ...	Nil	Nil
Methyl orange alkalinity " ...	13.0	12.2
Total solids " ...	15.0	17.0
Temporary hardness " ...	7.5	7.0
Permanent hardness " ...	2.5	2.5
Total hardness " ...	10.0	9.5
Chlorine " ...	1.1	0.7
Ammoniacal nitrogen " ...	Trace	0.006
Albuminoid nitrogen " ...	0.012	0.002
Oxygen absorbed (Tidy's test) " ...	0.060	0.043
Nitrates qualitative ...	Nil	Nil
Nitrites " ...	Nil	Nil
Sulfates " ...	Present	Present
Phosphates " ...	Nil	Nil
Iron and poisonous metals " ...	Nil	Nil
Colour	Whitish	Whitish
Smell	None	None
PLANKTON :		
Blue-green algae standard cubic units/cc.	9	0
Green algae " "	84	0
Diatoms " "	3	10
Protozoa " "	95	77
Rotifers " "	1	0
Copepods " "	13	0
Amorphous matter " "	1,200	70
Total plankton " "	1,405	157
Predominant forms " "	<i>Anthophysa</i> 72 <i>Closterium</i> 32 <i>Spirogyra</i> 30 Dinoflagellate 14 <i>Cosmarium</i> 12 Unicellular green alga 10 <i>Cyclops</i> 12 Also 15 other organisms	<i>Anthophysa</i> 77 Diatoms—three forms No other organisms

NOTES: Borrow-pit 3 excavated 30th July. Borrow-pit 4 excavated 19th September.

These studies in pits 3 and 4, therefore, indicated possibly an inverse correlation between the density of *culicifacies* larvae and the total plankton, especially the planktonic forms of green and blue-green algae, and of amorphous matter. This seemed a possible deduction because (1) in both pits, as the density of *culicifacies* larvae declined that of the planktonic forms mentioned increased, and at any given time when the one was high and the other was low; (2) when the two pits presented the greatest contrast, on 25th September, the older one having the greater density of planktonic forms had the lower density of larvae and the younger pit showed the reverse condition, of high larval density and low planktonic content.

We had no complete proof, however, that there was here a case of actual cause and effect, for some external, *e.g.*, climatic, factor might be postulated to explain both fluctuations, which therefore happened to coincide. At any rate, the remarkable differences in total plankton, amorphous matter, and numbers of organisms, in conjunction with the differences in larval density suggested the need for further study.

Borrow-pits D2 to D19 (1940-1941).

In order further to test the interesting possibilities suggested by observations in pits 1, 3, and 4, we decided to study a much larger number in 1940-1941, excavating two standard pits a month, from May to January, as already described above.

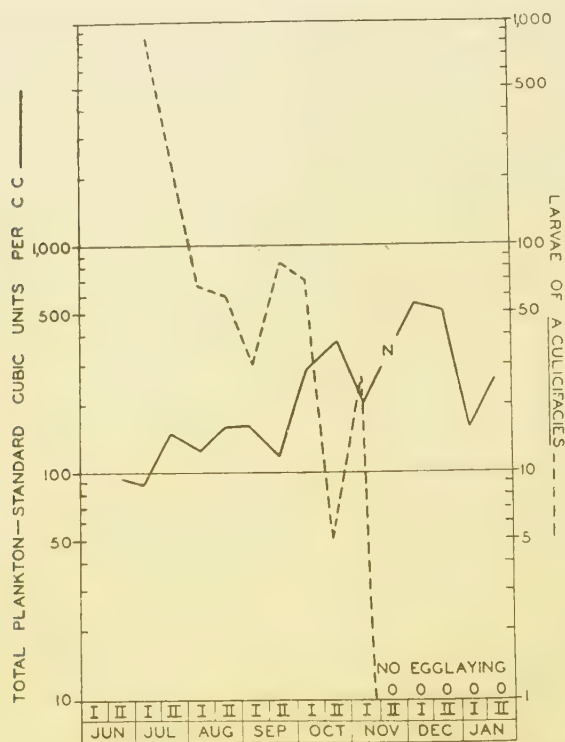


Fig. 3. Borrow-pit D3 (1940-1941), dug on 20th May 1940. Seepage started only in second half of June. Note in this and subsequent charts inverse correlation between growth of total plankton and reduction in *culicifacies*. N=No examination.

The collections of *culicifacies* larvae in these pits are shown in Table III. We have already noted that in each pit, regardless of season, the highest numbers of *culicifacies* larvae were present when the pit was young, and there was always a decline as the pit became older. Again, at any given time, the greatest density of *culicifacies* larvae was always in the newest pits.

In size and depth the pits were all alike. No higher vegetation was present in any of them, but occasional growths of blue-green algae (*Cylindrospermum*) were seen. In D3, excavated in May, there was a good growth of flocculent blue-green algal masses on 6th July, much less the following week, and but scanty amounts until 26th October, when it disappeared. In this pit *culicifacies* larvae were abundant when macroscopic blue-green algal masses were also abundant. In D5, a June pit, the appearance of blue-green algae between 27th July and 26th October coincided with a decrease in *culicifacies* density. No macroscopic green algae were seen in any of the other pits at any time.

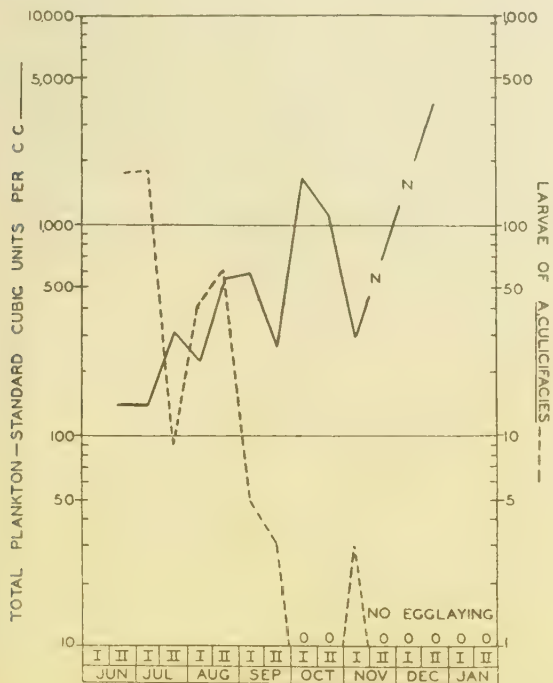


Fig. 4. Borrow-pit D5 (1940-1941), dug on 20th June 1940. Seepage started immediately. Note higher total plankton and quicker disappearance of *culicifacies* than in pit D3. N=No examination.

No larvivoracious fishes were seen, although once two bottom-feeding fishes somehow came into one of the pits, perhaps overland from a pool near by. They did no harm before their removal. All pits were singularly free from predatory insects, which certainly had nothing whatever to do with the decline in larval density. Frequently, when *culicifacies* larva density had become low or nil, there were good numbers of *subpictus* larvae present (e.g., on 26th October).

As to chemical characters, only those tests that we ourselves carried out immediately after collecting the samples were recorded and not the tests done in previous seasons at the King Institute, in Guindy. The findings in the various pits were very similar. Hydrogen ion concentration varied between 6.6 and 8.2, usually from 6.8 to 7.2. Residual pH was almost always 7.8. CO_2 was always present in ranges between 0.4 and 1.8 parts per 100,000. Dissolved oxygen was usually near the saturation point. Bicarbonate alkalinity was low in June and July, but the ground water appeared to become more alkaline as the season advanced. Pits excavated in later months started with higher alkalinities than were characteristic of the older pits earlier in the season. Normal carbonates were not found (see Table VI).

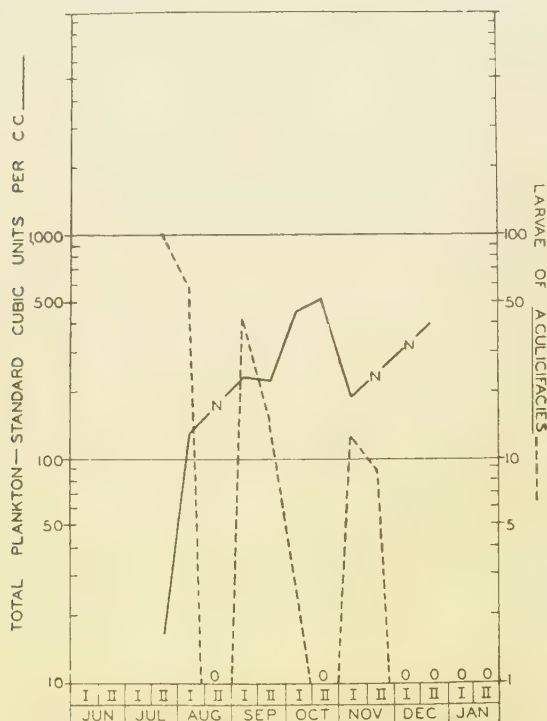


Fig. 5. Borrow-pit D7 (1940-1941), dug on 20th July 1940. N=No examination.

As to plankton, the pits were so much alike that they may all be considered together, noting occasional exceptions. Space will not permit the printing of all data, but in Table VI we have shown those for pits D3, D8, and D15, which were representative of all the pits.

Cyanophyceae.—Microscopic blue-green algae were rare, but in the May pits scanty forms were seen on 6th July, 20th July (*Oscillatoria*), and on 27th September (*Coelosphaerium*), without apparent relationship to breeding. In D5 blue-green algae were observed on three occasions successively from 27th July. The forms were *Aphanocapsa* and *Cylindrospermum*. The first appearance coincided with a reduction of *culicifacies*.

Chlorophyceae.—These were present throughout in the May and June pits, but in other pits they were scanty. The common forms were *Closterium*, *Gonium*, *Pediastrum*, *Cosmarium*, *Staurastrum*, and *Scenedesmus*. No relation to *culicifacies* was noted.

Diatoms.—Scanty in all pits. No relation to larval density.

Protozoa.—These were more abundant and in greater variety than other forms. They gradually increased in numbers as the season advanced. *Anthophysa* was the commonest form and was usually present but did not seem to have any relation to *culicifacies* breeding. *Arcella*, an undetermined dinoflagellate, *Euglena*, and *Coleps*, were the other common forms. Once (18th October) when the dinoflagellate was very abundant in the July pit, *culicifacies* larvae were entirely absent. Otherwise, no particular relationship was noticed, except, of course, that as *culicifacies* declined, the total quantity of Protozoa increased.

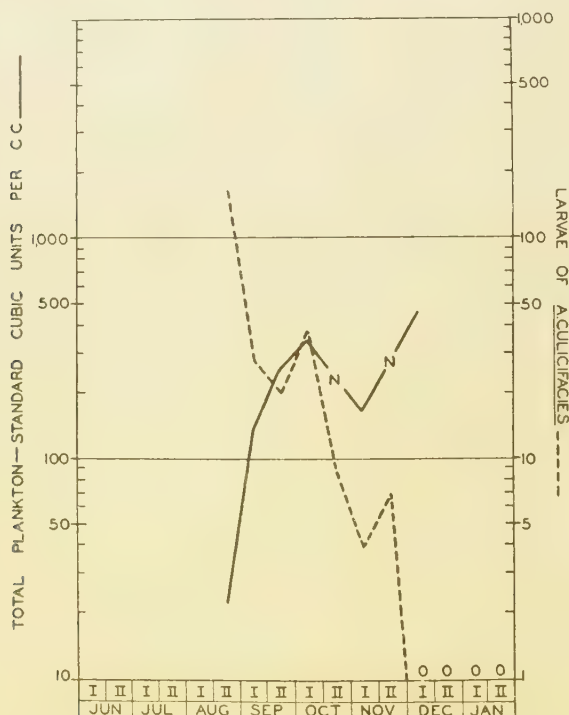


Fig. 6. Borrow-pit D8 (1940–1941), dug on 20th August 1940. N=No examination.

Rotifers, *Copepods*, and *Daphnia*.—These were commonly present, sometimes in abundance. No relation to *culicifacies* breeding was noticed.

Amorphous matter.—In all the pits, amorphous matter increased as the pits became older. Some pits had more amorphous matter than others.

Total plankton.—In all pits, generally speaking, there was a gradual increase of total plankton (including amorphous matter) with age of pit and this increase appeared to be closely related to the decline in *culicifacies* breeding (figs. 3, 4, 5, and 6). D3, the May pit (Fig. 3), had less total plankton than D5, the June pit

(fig. 4), although both filled with seepage water about the same time. It is interesting to note that the first disappearance of *culicifacies* occurred in the May pit (November—second half) much later than in the June pit (October—first half). The total plankton, soon after excavation, was generally low, the figures in standard units per cc. being as follows:—

June pit	July pit	Aug. pit	Sept. pit	Oct. pit	Nov. pit	Dec. pit	Jan. pit
135	16	22	53	18	Not examined	142	130

These figures are low compared with those taken simultaneously at given times in older pits. For instance, on 25-26th October, data for the total plankton in the several pits in standard units were as follows:—

May pit	June pit	July pit	Aug. pit	Sept. pit	Oct. pit
370	1,106	515	Not examined	713	18

Résumé.—It appears clear that the main point of difference between new pits dug in any month and the old pits of earlier months was in the plankton. Total plankton and total amorphous matter were generally low in the new pits. Blue-green algae, wherever they occurred in the plankton, seemed to be associated with a decline in *culicifacies* breeding.

Discussion.

It seemed clear from our observations that none of the following factors had any definite relationship to the fluctuations in density of *culicifacies* larvae in the borrow-pits we studied: rainfall, predators, macroscopic vegetation, hydrogen ion concentration, carbon dioxide, dissolved oxygen, alkalinity, hardness, chlorine, ammoniacal nitrogen, nitrates, nitrites, sulphates, phosphates, iron, and poisonous metals. As regards albuminoid nitrogen and oxygen absorbed, which are to some extent measures of total organic matter in suspension, there was perhaps some relationship. In borrow-pit 1, these two factors increased to relatively high figures just prior to the sudden decline in *culicifacies* breeding on 12th September 1938. In borrow-pits 3 and 4, in September 1939, when a comparative study was made, the new pit (no. 4) with 18 times the density of *culicifacies* larvae, showed a distinctly lower albuminoid nitrogen content and somewhat less oxygen absorbed. Our data are not conclusive in this regard, but at least the findings are in accord with those regarding plankton.

A careful analysis of our data as regards the ratio of free to bound and to half-bound carbon dioxide did not reveal any relationship between this ratio and fluctuations in *culicifacies* breeding.

As regards plankton, however, there were indications of a relationship. Blue-green algae, whenever they occurred in the plankton, appeared to be associated with the declining phase of *culicifacies*. Green algae, diatoms, protozoans, rotifers, and copepods did not show any clear correlation. But the amorphous organic matter

TABLE VII.
Relationship between Fluctuations of Planktonic Organisms to those of A. culicifacies Larvae from Data for Seven Borrow-pits.

Description	Positive association			Negative association		Total positive	Total negative	Total positive and negative association	Mean	Standard deviation of mean \sqrt{pq}	Significant or not
	A	B		C	D						
Blue-green algae ...	2	8		6	10	10	16	26	13.0	2.55	No
Green algae ...	11	14		12	8	25	20	45	22.5	3.35	No
Diatoms ...	10	13		11	9	23	20	43	21.5	3.28	No
Protozoa ...	10	11		18	18	21	36	57	28.5	3.77	Just significant
Rotifers ...	10	10		14	10	20	24	44	22.0	3.30	No
Copepods ...	15	15		13	9	30	22	52	26.0	3.60	No
Amorphous matter ...	10	7		24	16	17	40	57	28.5	3.77	Significant
Total plankton ...	8	7		24	19	15	43	58	29.0	3.81	Significant

NOTES: A—both numbers of larvae and counts of planktonic organisms showed an increase. B—both numbers of larvae and counts of planktonic organisms showed a decrease. C—organisms increased, larvae decreased. D—organisms decreased, larvae increased.

present in the water and more especially the total plankton, showed a progressive increase in almost every pit. They were nearly always associated with a decline in the larval density of *culicifacies*.

The data for planktonic forms have been further analysed and presented in Table VII. This table shows the number of times the increase or decrease in each group of organisms was associated with a simultaneous increase or decrease in the larval density of *culicifacies*. For purposes of this table, the data from seven borrow-pits (3, 4, D3, D5, D7, D8 and D16) have been consolidated. If two consecutive visits to the pits were separated by more than three weeks, those figures have been disregarded. We have not included those cases when for two consecutive weeks there was a negative (zero) figure for either the factor or the larvae. The purpose of this table is to examine the fluctuation, that is increase or decrease of the factors in relation to concurrent changes in density of *culicifacies* larvae. It is seen that as regards green algae, diatoms, and copepods, there were slightly more positive associations than negative associations, and that in the case of blue-green algae, protozoans and rotifers, there were slightly more negative than positive associations. Regarding amorphous matter and total plankton, however, the negative associations were distinctly higher than the positive associations.

These figures have been statistically tested by the standard deviation method formula, $\sqrt{N_{pq}}$, in order to find out if the differences were significant and fell outside the range of odds of 1 : 1, that is, whether the differences were unlikely to be due to chance. It is seen that the differences regarding blue-green algae, green algae, diatoms, rotifers, and copepods are definitely not significant. For Protozoa the difference was just significant and needs further study. But as regards amorphous matter and total plankton, the differences were clearly significant and unlikely to have been due to chance. In the case of amorphous matter, fluctuations in the larval density of *culicifacies* were negatively associated 67.8 per cent. of times. This figure for total plankton was 72.9 per cent.

The data regarding total plankton and *culicifacies* larvae are further analysed in a different way in Table VIII below, consolidating data for 10 borrow-pits, viz., D3, D5, D7, D8, D10, D12, D16, D19, 3, and 4.

TABLE VIII.

Relationship between total Plankton and average Number of A. culicifacies Larvae.

Total plankton range, standard cubic units, per cc.	Number of collections	Average number of <i>culicifacies</i> larvae per collection
Below 100	8	158
101—200	24	63
201—300	11	28
301—400	5	25
401—and above	41	10
401—800	26	11
801—and above	15	7

This table shows that the average number of *culicifacies* larvae per collection fall off as the total plankton increases.

The above points seem to indicate rather strongly that the decreasing attractiveness of the borrow-pits, as they became older, to *culicifacies* larvae, was related to the growth of planktonic forms, in other words, of total organic matter present, quite apart from the external seasonal factors. In a freshly dug pit, with the least organic matter, *culicifacies* larvae were generally found in good numbers, and, conversely, in older pits with most organic matter, these larvae were absent or in small numbers.

We know by careful observation that the decline in density was not due to failure of eggs to develop. The density became low because eggs were not laid. But we cannot say in what way the ovipositing females were repelled by the organic matter in the water. It is quite possible that the total organic matter present determined some undetected chemical or physical changes. Or it may be that, along with the growth of organic matter but independently of it, certain other factors developed which repelled the ovipositing female. In other words, the total organic matter may have directly or indirectly repelled the female, or, perhaps, may not have been even an indirect factor. But there was certainly a negative association between larval density of *culicifacies* and total plankton and amorphous matter in seepage-filled borrow-pits.

Summary and Conclusions.

(1) In seepage-filled borrow-pits in South India it was observed that there was a progressive decline in the density of larvae of *Anopheles culicifacies*, Giles, as the pits became older. The largest numbers of larvae were found soon after water entered the newly-dug pits.

(2) There was less ovipositing by *culicifacies* in older pits than in new ones dug late in the irrigation season. Newer pits seemed definitely more attractive in this species than older ones. These newer pits sheltered more *culicifacies* larvae late in the season than the older pits.

(3) The decline of *culicifacies* larva density in a borrow-pit seemed to be due mainly to factors internal to the pits. There was no evidence of the influence of external factors, except from October to January, when perhaps meteorological influences supplemented the internal factors. The attractiveness of new borrow-pits to *culicifacies* appeared to be due mainly to internal factors.

(4) Certain simple factors studied did not seem to have any significance in relation to *culicifacies* density in the pits. Rainfall, predators, macroscopic vegetation, pH, CO₂, dissolved oxygen, bicarbonate alkalinity, ratio of free to bound and half bound CO₂, hardness, chlorine, ammoniacal nitrogen, nitrates, nitrites, sulfates and iron, appeared to have no significance in this regard. Albuminoid nitrogen and oxygen absorbed perhaps had some significance, which was not clear.

(5) Among planktonic organisms, the individual groups of organisms, such as green algae, diatoms, rotifers, and copepods, definitely showed no relation to *culicifacies* breeding. Protozoa as a group appeared to be negatively associated to a slight degree. Blue-green algae also seemed to have a negative association.

(6) Amorphous organic matter and total plankton, however, showed statistically significant negative association with larval density of *culicifacies*. The decline in *culicifacies* larvae was clearly associated with increase in total plankton and amorphous matter. The attractiveness of new borrow-pits also seemed to be related to their low total plankton content.

(7) The exact manner in which the total organic matter acted as an inhibitory factor against *culicifacies* breeding was not determined.



Fig. 1. Borrow pit No. 1. June 1938 -January 1939.



Fig. 2. A general view showing arrangement of special borrow pits in 1940-1941 season. Pit No. D/16 in foreground.

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COLLECTIONS RECEIVED.

The following collections were received by the Imperial Institute of Entomology between 1st July and 30th September, 1941 :—

AGRICULTURAL RESEARCH LABORATORIES, WAD MEDANI :—41 Coleoptera and 35 Lepidoptera ; from the Sudan.

Mr. H. E. BOX :—21 Diptera and 20 pupa-cases, 350 Parasitic Hymenoptera and 200 cocoons ; from the Gold Coast.

Mr. R. G. FENNAH :—38 Parasitic Hymenoptera ; from the British West Indies.

Mr. D. VESEY FITZGERALD :—38 Parasitic Hymenoptera ; from Malaya.

FOREST PRODUCTS RESEARCH LABORATORY :—6 Coleopterous larvae ; from England.

Mr. J. L. FROGGATT, Government Entomologist :—28 Diptera, 16 Coleoptera, 6 Parasitic Hymenoptera, 10 other Hymenoptera, 35 Lepidoptera, and 7 Rhynchota ; from New Guinea.

Mr. G. H. E. HOPKINS, Medical Entomologist :—34 *Glossina* and 16 other Diptera ; from Uganda.

Mr. R. A. LEVER, Government Entomologist :—26 Diptera, 111 Coleoptera and 30 early stages, 152 Parasitic Hymenoptera, 32 Lepidoptera, 40 Thysanoptera, 8 species of Coccidae, 2 species of Aleurodidae, 63 other Rhynchota, 12 Orthoptera, 7 Chrysopidae, and 5 Odonata ; from the Fiji Islands.

Dr. E. A. LEWIS, Veterinary Entomologist :—12 *Glossina* puparia ; from Kenya Colony.

MINISTRY OF SUPPLY, LONDON :—20 Coleoptera ; from India.

QUEENSLAND FOREST SERVICE, BRISBANE :—16 Parasitic Hymenoptera ; from Queensland.

Mr. J. M. WATERSTON, Plant Pathologist :—19 Coleoptera ; from Bermuda.

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